AFGL-TR-79-0214
ENVIRONMENTAL RESEARCH PAPERS, NO. 676

LEVEL II

ADA085951

Models for the Aerosols of the Lower Atmosphere and the Effects of Humidity Variations on Their Optical Properties

ERIC P. SHETTLE
ROBERT W. FENN

DTIC ELECTE JUN 25 1980 S C D

20 September 1979

Approved for public release; distribution unlimited.

OPTICAL PHYSICS DIVISION PROJECT 7670
AIR FORCE GEOPHYSICS LABORATORY
HANSCOM AFB, MASSACHUSETTS 01731

AIR FORCE SYSTEMS COMMAND, USAF

80 6 25 031

This report has been reviewed by the ESD Information Office (OI) and is releasable to the National Technical Information Service (NTIS).

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

John Howard

Chief Scientist

Qualified requestors may obtain additional copies from the Defense Documentation Center. All others should apply to the National Technical Information Service.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFGL-TR-79-0214	2. GOVT ACCESSION NO. AD-A085 957	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) (6) MODELS FOR THE AEROSOLS OF THE LOWER ATMOSPHERE AND THE EFFECTS OF HUMIDITY VARIATIONS ON THEIR OPTICAL PROPERTIES		5. TYPE OF REPORT & PERIOD COVERED Scientific. Interim.
		6. PERFORMING ORG. REPORT NUMBER ERP No. 676
7. AUTHOR(s) (10) Eric P. Shettle, Robert W. Fenn		8. CONTRACT OR GRANT NUMBER(s) (11) 20 Sep 79
9. PERFORMING ORGANIZATION NAME AND ADDRESS Air Force Geophysics Laboratory (OP) Hanscom AFB Massachusetts 01731		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62101F (16) 76701401 (17) 14
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Geophysics Laboratory (OP) Hanscom AFB Massachusetts 01731		12. REPORT DATE 20 September 1979
		13. NUMBER OF PAGES 94
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (12) 94		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

(14) AFGL-TR-79-0214, AFGL-ERP-676

18. SUPPLEMENTARY NOTES

(9) Environmental research papers

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aerosols
Atmospheric optical properties
Light scattering
Infrared
Attenuation
Radiative transfer

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Aerosol models have been developed for the lower atmosphere. These models are representative of conditions found in rural, urban, and maritime air masses. The changes in the aerosol properties with variations in the relative humidity are discussed. To describe the aerosol optical properties in the extreme of 100 percent relative humidity, several fog models are presented. For each model the coefficients for extinction, scattering, and absorption, the angular scattering distribution, and other optical parameters have been computed for wavelengths between 0.2 and 40 μm. These aerosol models are

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

409578

20. (Cont)

presented together with a review of their experimental basis. The optical properties of these models are discussed and some comparisons of the model with experimental measurements are presented.

Preface

We would like to thank several individuals who helped with this report, in particular: Fred Volz for his advice on the aerosol refractive indices and his general comments on the aerosol models, Frank Gibson for his work in developing the Fog Models, and Barry Siegel for his assistance with the computer programming.

Contents

Illustrations

Tables

Tables

Models for the Aerosols of the Lower Atmosphere and the Effects of Humidity Variations on Their Optical Properties

1. INTRODUCTION

Propagation of electromagnetic radiation at optical/infrared frequencies through the atmosphere is affected by absorption and scattering by air molecules and by particulate matter (haze, dust, fog, and cloud droplets) suspended in the air. Scattering and absorption by haze particles or aerosols becomes the dominant factor in the boundary layer near the earth's surface, especially under low visibility conditions.

Atmospheric aerosol particles in the atmosphere vary greatly in their concentration, size, and composition, and consequently in their effects on optical and IR radiation.

There are many scientific and technical reasons why it is necessary to develop models for atmospheric aerosols. They are needed to make estimates of the transmittance, of angular light scattering distribution, of contrast reduction, sky radiance, or other atmospheric optical properties or effects.

Models for the optical properties of aerosols have been developed previously at AFGL and elsewhere.[1-7*] For the lower layer near the earth's surface, these models define an average continental type aerosol whose concentration can be scaled according to surface visibility.

(Received for publication 20 September 1979)

*Due to the large number of references cited in this report, they will not be footnoted. See References, pages 89 through 94.

Preceding Page Blank

The aerosol properties in these models were based on experimental measurements that were made during and prior to the mid-1960's. At that time there was sufficient experimental data available to define an average aerosol model with some different haze concentrations in the lower troposphere (up to a few km altitude) with exponential vertical decrease in particle concentration.

During the past decade, in this country and elsewhere, extensive additional measurements from ground as well as airborne platforms have been made of aerosol concentrations, their size distribution, and optical properties, to warrant the development of updated aerosol models that also describe some of the temporal and spatial variations in atmospheric aerosol distributions and properties. There are now sufficient experimental data to develop models for several different types of tropospheric aerosols, including the dependence of the aerosol properties on relative humidity.

Such updated models have been developed by Shettle and Fenn[8] and Toon and Pollack,[9] except both of these sets of models neglect the effects of relative humidity. The present report describes aerosol models for the lower atmosphere and their optical properties including a discussion of how the aerosol properties change as a function of relative humidity. The optical properties of the models are given for a number of wavelengths between 0.2 and 40 μm, and for several different relative humidities ranging from 0 to 99 percent. In addition four fog models are given for the droplet-condensation phase.

The models of the atmospheric aerosols and their optical properties presented below are based on a review of the available data on the nature of the aerosols, their sizes, their distribution, and variability. However, it must be emphasized that these models represent only a simple, generalized version of typical conditions. It is not practical to include all the details of natural aerosol distributions nor are existing experimental data sufficient to describe the frequency of occurrence of the different conditions. While these aerosol models were developed to be as representative as possible of different atmospheric conditions, the following point should be kept in mind when using any such model: Given the natural variability of the atmospheric aerosols almost any aerosol model is supported by some measurements and no model (or set of models) will be consistent with all measurements.

2. MODELS FOR THE PHYSICAL PROPERTIES OF THE AEROSOLS

2.1 Model Size Distribution

The size distributions for the different aerosol models are represented by one or the sum of two log-normal distributions:

$$n(r) = \frac{dN(r)}{dr} = \sum_{i=1}^{2} \left(\frac{N_i}{\ln(10) \cdot r \cdot \sigma_i \sqrt{2\pi}} \right) \exp \left[- \frac{(\log r - \log r_i)^2}{2\sigma_i^2} \right]^* \quad (1)$$

where N(r) is the cumulative number density of particles of radius r; σ is the standard deviation; r_i, N_i are the mode radius and the number density with r_i. This form of distribution function represents the multimodal nature of the atmospheric aerosols that has been discussed in various studies.[10-14] While Harris and McCormick[15] have suggested using the sum of four log-normal distributions and Davies[16] has used the sum of as many as seven log-normal distributions to fit a measured aerosol size distribution, Whitby and Cantrell[17] have shown that two modes are generally adequate to characterize the gross features of most aerosol distributions. While a third component is often necessary to represent the Aitken nuclei especially near sources of combustion particulates, their effect on the optical properties is small and will be neglected.

There are measurements showing the composition of the atmospheric particulates depending on their size,[18,19] and using a bimodal size distribution offers the possibility of treating the composition of the individual modes separately. However, there is, in general, insufficient experimental data to uniquely define different refractive index models for the different size ranges, along with differing dependence on relative humidity.

For the maritime conditions, there is evidence[20] showing that the large particles are almost exclusively of oceanic origin and the smaller particles are predominantly of the same composition as the continental aerosols so that we do not differentiate between the two size ranges in terms of their composition.

Four different aerosol models for the atmospheric boundary layer near the earth's surface have been developed. They differ in particle size distribution and particle refractive index. Table 1 lists the parameters defining the size distributions in accordance with Eq. (1) for these models.

The choices of N in Table 1 are normalized to correspond to 1 particle/cm^3. The actual size distributions can be re-normalized to give the correct extinction coefficients for the altitude and for the visibility being used. The continental and oceanic components of the maritime model can be used in various proportions depending on the prevailing winds—particularly in coastal regions. The basis for the characterization of each of the aerosol models is discussed in Sections 2.3 through 2.6.

---

*Following the usual convention, log is the logarithm to the base 10 and ln is the logarithm to the base e.

Table 1. Characteristics of the Aerosol Models of the Lower Atmosphere

Aerosol Model	Size Distribution			Type
	N_i	r_i*	σ_i	
RURAL	0.999875 0.000125	0.03 0.5	0.35 0.4	Mixture of Water-Soluble and Dust-Like Aerosols
URBAN	0.999875 0.000125	0.03 0.5	0.35 0.4	Rural Aerosol Mixture with Soot-Like Aerosols
MARITIME				
Continental Origin	1.	0.03	0.35	Rural Aerosol Mixture
Oceanic Origin	1.	0.3	0.4	Sea Salt Solution in Water
TROPOSPHERIC	1.	0.03	0.35	Rural Aerosol Mixture

*These mode radii correspond to moderate humidities (70 to 80%); values of r_i as function of humidity are given in Table 2.

Table 2. Mode Radii for the Aerosol Models as a Function of Relative Humidity

Relative Humidity	Tropospheric	Rural		Maritime	Urban	
	r_1	r_1	r_2		r_1	r_2
0%	0.02700	0.02700	0.4300	0.1600	0.02500	0.4000
50%	0.02748	0.02748	0.4377	0.1711	0.02563	0.4113
70%	0.02846	0.02846	0.4571	0.2041	0.02911	0.4777
80%	0.03274	0.03274	0.5477	0.3180	0.03514	0.5805
90%	0.03884	0.03884	0.6462	0.3803	0.04187	0.7061
95%	0.04238	0.04238	0.7078	0.4606	0.04904	0.8634
98%	0.04751	0.04751	0.9728	0.6024	0.05996	1.1691
99%	0.05215	0.05215	1.1755	0.7505	0.06847	1.4858

2.2 Effects of Humidity Variations on Aerosol Properties

As the relative humidity increases, water vapor condenses out of the atmosphere onto the particulates suspended in the atmosphere. This condensed water increases the size of the aerosols and changes their composition and their effective refractive index. The resulting effect of the aerosols on the absorption and scattering of light will correspondingly be modified. There have been a number of studies of the change of aerosol properties as a function of relative humidity.[21-28] The most comprehensive of these, especially in terms of the resulting effects on the aerosol optical properties is the work of Hänel.[26-28]

The change in the particulate size is related to the relative humidity by (following Hänel's notation)

$$r(a_w) = r_o \left[1 + \rho \cdot \frac{m_w(a_w)}{m_o} \right]^{1/3} \tag{2}$$

where

r_o is the dry particle radius,

ρ is the particle density relative to that of water,

$m_w(a_w)$ is the mass of condensed water,

m_o is the dry particle mass, and

a_w is the water activity which is essentially the relative humidity f, corrected for curvature of the particle surface.

$$a_w = f \cdot \exp\left(\frac{-2\sigma V_w}{R_w \cdot T \cdot r}\right) \tag{3}$$

where

σ = surface tension on the wet particle surface,

V_w = specific volume of water,

R_w = specific gas constant for water,

T = absolute temperature (°K).

For room temperature ($T = 298°K$),

$$\frac{2\sigma V_w}{R_w T} = 0.001056 \text{ [micron] (Hänel,}^{28}\text{ page 126)}.$$

Typical atmospheric temperatures are as much as 20 percent lower but, for particle radii $r > 0.01\ \mu m$, this leads to errors of less than 2 percent in curvature effect so Eq. (3) can be rewritten as

$$a_w = f \cdot \exp\left(\frac{-0.001056}{r(a_w)}\right), \tag{4}$$

where r is in μm and where the dependence of r on a_w has been made explicit.

There are a number of studies on change in size or mass of aerosol particles as a function of relative humidity for various electrolytes[21, 25] and natural atmospheric particulates.[11, 12, 15, 17, 18, 19, 22, 23, 26, 28, 29, 30] Hänel[28] (in his Table IV) has tabulated his and other measurements of $\frac{m_w(a_w)}{m_o}$ vs a_w for various types of

natural aerosols. However, even with this data on the relative mass of condensed water for use in Eq. (2), it is not possible to combine Eq. (2) and (4) into an exact analytic expression giving aerosol radius, r, as an explicit function of relative humidity, because a_w appears on both sides of Eq. (4). Various approximations have been developed.[25, 28, 31] However, these tend to breakdown for small particle sizes and high humidities.

To avoid the limitations of these approximations, Eq. (2) and (4) were used alternately in an iterative manner until they converged (typically 5 or 6 iterations) starting with $a_w \approx f$ on the right side of Eq. (2). Starting with $r = r_o$ in Eq. (4) leads to the same result. To interpolate between Hänel's[28] data for different water activities, a_w^i and a_w^{i+1}, it was assumed that

$$\frac{m_w(a_w^i)}{m_w(a_w^{i+1})} \approx \left(\frac{1-a_w^i}{1-a_w^{i+1}}\right)^{\nu_i} . \tag{5}$$

Once the wet aerosol particle size is found from Eq. (2) and (4), the effective complex refractive index, n, is simply the volume weighted average of the refractive indexes of the dry aerosol substance, n_o, and water, n_w. Equivalently, this can be written as

$$n = n_w + (n_o - n_w) \cdot \left[\frac{r_o}{r(a_w)}\right]^3 . \tag{6}$$

For the refractive index of water, the survey of Hale and Querry[32] was used. While there are some minor differences between the optical constants in Hale and Querry's survey and the more recent measurements[33, 34] these differences are comparable with the experimental errors and are small compared with the other uncertainties in the model parameters. These refractive index data are shown in Figure 1.

2.3 Rural Aerosol Model

The "Rural Model" is intended to represent the aerosol under conditions where it is not directly influenced by urban and/or industrial aerosol sources. The rural aerosols are assumed to be composed of a mixture of 70 percent of water soluble substance (ammonium and calcium sulfate and also organic compounds) and 30 percent dust-like aerosols. The refractive index for these components based on the measurements of Volz[35, 36] is shown in Figure 2 and tabulated in Table 3. These refractive index data weighted by the mixing ratio of the two components are consistent with other direct measurements,[37, 38] and with values inferred from in situ measurements.[39-41]

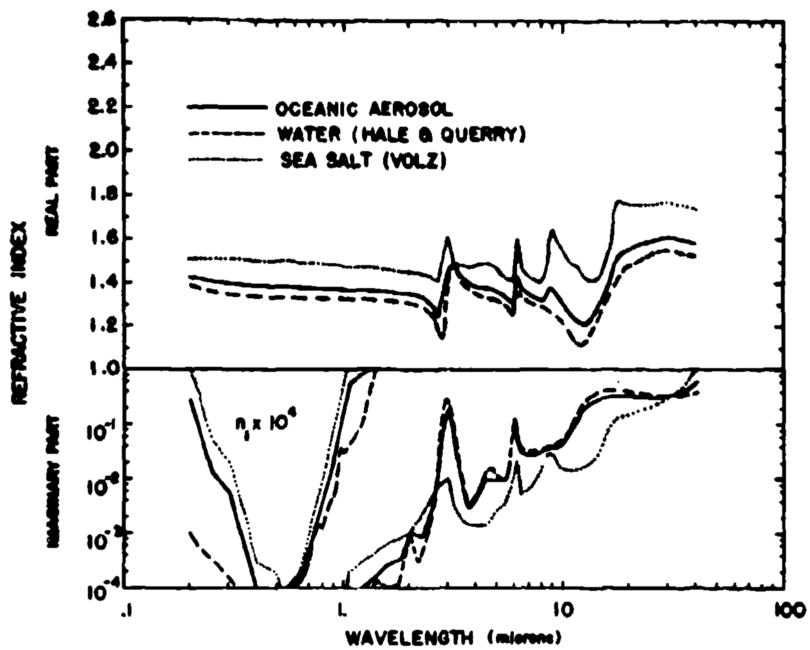

Figure 1. Refractive Index of Oceanic Aerosol, Water, and Sea Salt

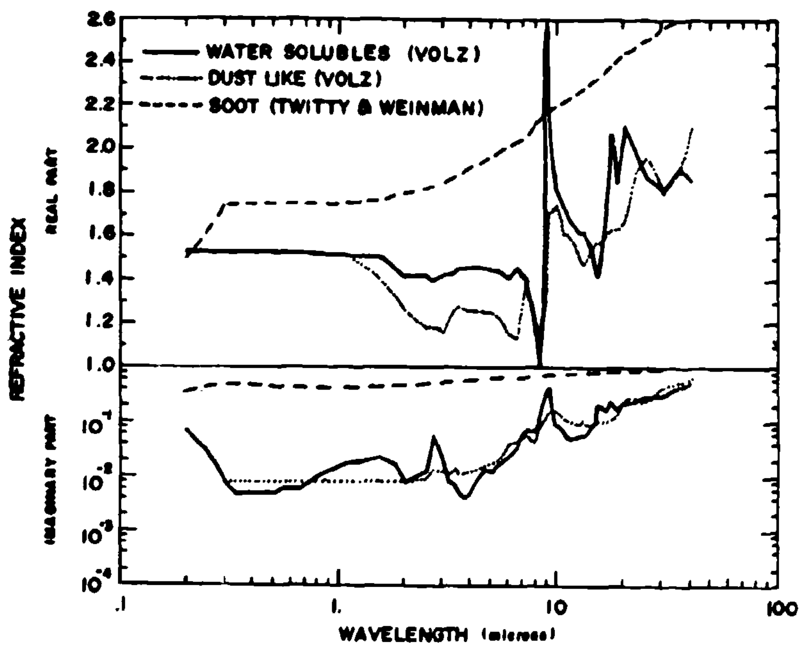

Figure 2. Refractive Index for the Dry Rural and Urban Aerosol Components

Table 3. Refractive Index for the Different Aerosol Components

WAVELENGTH (MICRONS)	WATER SOLUBLE		DUST-LIKE		SOOT		SEA SALT		WATER	
.2000	1.530	-7.00E-02	1.530	-7.00E-02	1.500	-.350	1.510	-1.00E-04	1.396	-1.10E-07
.2500	1.530	-3.00E-02	1.530	-3.00E-02	1.620	-.450	1.510	-5.00E-06	1.362	-3.35E-08
.3000	1.530	-8.00E-03	1.530	-8.00E-03	1.740	-.470	1.510	-2.00E-06	1.349	-1.60E-08
.3371	1.530	-5.00E-03	1.530	-8.00E-03	1.750	-.470	1.510	-4.00E-07	1.345	-8.45E-09
.4000	1.530	-5.00E-03	1.530	-8.00E-03	1.750	-.460	1.500	-3.00E-08	1.339	-1.86E-09
.4880	1.530	-5.00E-03	1.530	-8.00E-03	1.750	-.450	1.500	-2.00E-08	1.335	-9.69E-10
.5145	1.530	-5.00E-03	1.530	-8.00E-03	1.750	-.450	1.500	-1.00E-08	1.334	-1.18E-09
.5500	1.530	-6.00E-03	1.530	-8.00E-03	1.750	-.440	1.500	-1.00E-08	1.333	-1.96E-09
.6328	1.530	-6.00E-03	1.530	-8.00E-03	1.750	-.430	1.490	-2.00E-08	1.332	-1.46E-08
.6943	1.530	-7.00E-03	1.530	-8.00E-03	1.750	-.430	1.490	-1.00E-07	1.331	-3.05E-08
.8600	1.520	-1.20E-02	1.520	-8.00E-03	1.750	-.430	1.480	-3.00E-06	1.329	-3.29E-07
1.0600	1.520	-1.70E-02	1.520	-8.00E-03	1.750	-.440	1.470	-2.00E-04	1.326	-4.18E-06
1.3000	1.510	-2.00E-02	1.460	-8.00E-03	1.760	-.450	1.470	-4.00E-04	1.323	-3.69E-05
1.5360	1.510	-2.30E-02	1.400	-8.00E-03	1.770	-.460	1.460	-6.00E-04	1.318	-9.97E-05
1.8000	1.460	-1.70E-02	1.330	-8.00E-03	1.790	-.480	1.450	-8.00E-04	1.312	-1.15E-04
2.0000	1.420	-8.00E-03	1.260	-8.00E-03	1.800	-.490	1.450	-1.00E-03	1.306	-1.10E-03
2.2500	1.420	-1.00E-02	1.220	-9.00E-03	1.810	-.500	1.440	-2.00E-03	1.292	-3.90E-04
2.5000	1.420	-1.20E-02	1.180	-9.00E-03	1.820	-.510	1.430	-4.00E-03	1.261	-1.74E-03
2.7000	1.400	-5.50E-02	1.100	-1.30E-02	1.830	-.520	1.400	-7.00E-03	1.188	-1.90E-02
3.0000	1.420	-2.20E-02	1.160	-1.20E-02	1.840	-.540	1.610	-1.00E-02	1.371	-.272
3.2000	1.430	-8.00E-03	1.220	-1.00E-02	1.860	-.540	1.490	-3.00E-03	1.478	-9.24E-02
3.3923	1.430	-7.00E-03	1.260	-1.30E-02	1.870	-.550	1.480	-2.00E-03	1.422	-2.64E-02
3.5000	1.450	-5.00E-03	1.280	-1.10E-02	1.880	-.560	1.480	-1.60E-03	1.400	-9.40E-03
3.7500	1.452	-4.00E-03	1.270	-1.10E-02	1.900	-.570	1.470	-1.40E-03	1.369	-3.50E-03
4.0000	1.455	-5.00E-03	1.260	-1.20E-02	1.920	-.580	1.480	-1.40E-03	1.351	-4.60E-03
4.5000	1.460	-1.30E-02	1.260	-1.40E-02	1.940	-.590	1.490	-1.40E-03	1.332	-1.34E-02
5.0000	1.450	-1.20E-02	1.250	-1.60E-02	1.970	-.600	1.470	-2.50E-03	1.325	-1.24E-02
5.5000	1.440	-1.80E-02	1.220	-2.10E-02	1.990	-.610	1.420	-3.60E-03	1.298	-1.16E-02
6.0000	1.410	-2.30E-02	1.150	-3.70E-02	2.020	-.620	1.410	-1.10E-02	1.265	-.107
6.2000	1.430	-2.70E-02	1.140	-3.90E-02	2.030	-.625	1.600	-7.20E-02	1.363	-8.06E-02
6.5000	1.460	-3.30E-02	1.130	-4.20E-02	2.040	-.630	1.460	-5.00E-03	1.339	-3.92E-02
7.2000	1.400	-7.00E-02	1.400	-5.50E-02	2.060	-.650	1.420	-7.00E-03	1.312	-3.21E-02
7.9000	1.200	-6.50E-02	1.150	-4.00E-02	2.120	-.670	1.400	-1.30E-02	1.294	-3.39E-02
8.2000	1.010	-.100	1.130	-7.40E-02	2.130	-.680	1.420	-2.00E-02	1.286	-3.51E-02
8.5000	1.300	-.215	1.300	-9.00E-02	2.150	-.690	1.480	-2.60E-02	1.278	-3.67E-02
8.7000	2.400	-.290	1.400	-.100	2.160	-.690	1.600	-3.00E-02	1.272	-3.79E-02
9.0000	2.560	-.370	1.700	-.140	2.170	-.700	1.650	-2.80E-02	1.262	-3.99E-02
9.2000	2.200	-.420	1.720	-.150	2.180	-.700	1.610	-2.60E-02	1.255	-4.15E-02
9.5000	1.950	-.160	1.730	-.162	2.190	-.710	1.580	-1.80E-02	1.243	-4.44E-02
9.8000	1.870	-9.50E-02	1.740	-.162	2.200	-.715	1.560	-1.60E-02	1.229	-4.79E-02
10.0000	1.820	-9.00E-02	1.750	-.162	2.210	-.720	1.540	-1.50E-02	1.218	-5.08E-02
10.5910	1.760	-7.00E-02	1.620	-.120	2.220	-.730	1.500	-1.40E-02	1.179	-6.74E-02
11.0000	1.720	-5.00E-02	1.620	-.105	2.230	-.730	1.480	-1.40E-02	1.153	-9.68E-02
11.5000	1.670	-4.70E-02	1.590	-.100	2.240	-.740	1.480	-1.40E-02	1.126	-.142
12.5000	1.620	-5.30E-02	1.510	-9.00E-02	2.270	-.750	1.420	-1.60E-02	1.123	-.259
13.0000	1.620	-5.50E-02	1.470	-.100	2.280	-.760	1.410	-1.80E-02	1.146	-.305
14.0000	1.560	-7.30E-02	1.520	-8.50E-02	2.310	-.775	1.410	-2.30E-02	1.210	-.370
14.8000	1.440	-.100	1.570	-.100	2.330	-.790	1.430	-3.00E-02	1.258	-.396
15.0000	1.420	-.200	1.570	-.100	2.330	-.790	1.450	-3.50E-02	1.276	-.402
16.4000	1.750	-.160	1.600	-.100	2.360	-.810	1.560	-9.00E-02	1.346	-.427
17.2000	2.080	-.240	1.630	-.100	2.380	-.820	1.740	-.120	1.386	-.429
18.0000	1.980	-.180	1.640	-.115	2.400	-.825	1.780	-.136	1.423	-.426
18.5000	1.850	-.170	1.640	-.120	2.410	-.830	1.770	-.135	1.443	-.421
20.0000	2.120	-.220	1.680	-.220	2.450	-.850	1.760	-.152	1.480	-.393
21.3000	2.060	-.230	1.770	-.280	2.460	-.860	1.760	-.165	1.491	-.379
22.5000	2.000	-.240	1.900	-.280	2.480	-.870	1.760	-.180	1.506	-.370
25.0000	1.880	-.280	1.970	-.240	2.510	-.890	1.760	-.265	1.531	-.356
27.9000	1.840	-.290	1.890	-.320	2.540	-.910	1.770	-.275	1.549	-.339
30.0000	1.820	-.300	1.800	-.420	2.570	-.930	1.770	-.300	1.551	-.320
35.0000	1.920	-.400	1.900	-.500	2.630	-.970	1.760	-.560	1.532	-.326
40.0000	1.860	-.500	2.100	-.600	2.690	-1.000	1.740	-1.000	1.519	-.385

In the preliminary version of these models,[8] the water-soluble and dust-like components were treated separately and the results of the Mie scattering calculations on individual components were combined. To reduce the calculations for the current models, which now are done as a function of humidity, the individual aerosol particles were considered to be a homogeneous combination of the different types of substance—as many natural aerosols are.[42] The resulting refractive index for the composite rural aerosol is given in Table 3. However, Bergstrom[43] has argued that using such mean refractive indexes in determining the optical properties will result in errors.

However, it should be noted that using this composite refractive index and Shettle and Fenn's[8] rural aerosol size distribution and comparing these results for the scattering and absorption coefficients with those based on separate calculations for the different aerosol types, one finds only a 5 percent difference except for the scattering minimum at 8.2 μm where the difference was 16 percent.

The parameters for the rural model size distribution given in Table 1 fall within what Whitby and Cantrell[17] give as a typical range of values for the accumulation and coarse particle modes.

The resulting number density distribution, $n_{(r)}$, is shown in Figure 3. While this size distribution approximates a r^{-4} power law for radii between 0.1 and 20 μm,[44,45] there are some fluctuations about a slope of -4 because of the bimodal nature of the distribution.[46] The major change from the earlier version of the rural model[8] is that the number density of the very small ($r < 0.5\ \mu$m) particles is more accurately represented.

To allow for the dependence of the humidity effects on the size of the dry aerosol, the growth of the aerosol was computed separately for the accumulation and coarse particle components using Hänel's model No. 6 water uptake data. In accounting for the aerosol growth in Eq. (2), changes in the width of the size distribution were assumed negligible so only the mode radius, r_i, was modified by humidity changes. The effective refractive indexes for the two size components were then computed from Eq. (6) as a function of relative humidity. The cumulative number density and the volume distribution are shown in Figures 4 and 5 respectively for several different relative humidities. The refractive index as a function of wavelength and relative humidity is given in Table 4.

2.4 Urban Aerosol Model

In urban areas the air with a rural aerosol background is primarily modified by the addition of aerosols from combustion products and industrial sourc[illegible] [illegible]e urban aerosol model therefore was taken to be a mixture of the rural aerosol with carbonaceous aerosols. The sootlike aerosols are assumed to have the same size distribution as both components of the rural model. The proportions of the sootlike

aerosols and the rural type of aerosol mixture are assumed to be 20 percent and 80 percent respectively. The refractive index of the sootlike aerosols was based on the soot data in Twitty and Weinman's[47] survey of the refractive index of carbonaceous materials. As with the rural model, a composite urban aerosol refractive index was determined at each wavelength. These values are given in Table 3.

The change in aerosol was based on Hänel's[28] urban aerosol data (his Model 5) and is given in Table 2. The resulting refractive indexes as a function of relative humidity are given in Table 5.

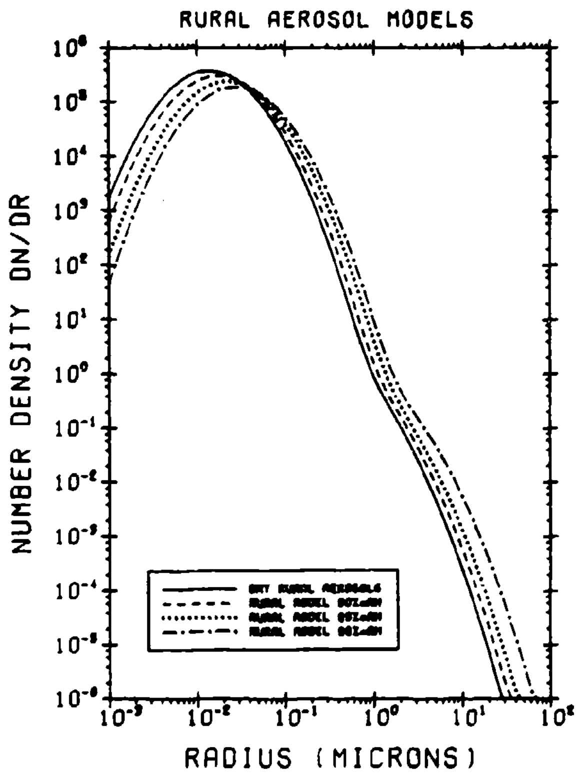

Figure 3. Aerosol Number Distribution (cm^{-3} μm^{-1}) for the Rural Model at Different Relative Humidities With Total Particle Concentrations Fixed at 15,000 cm^{-3}

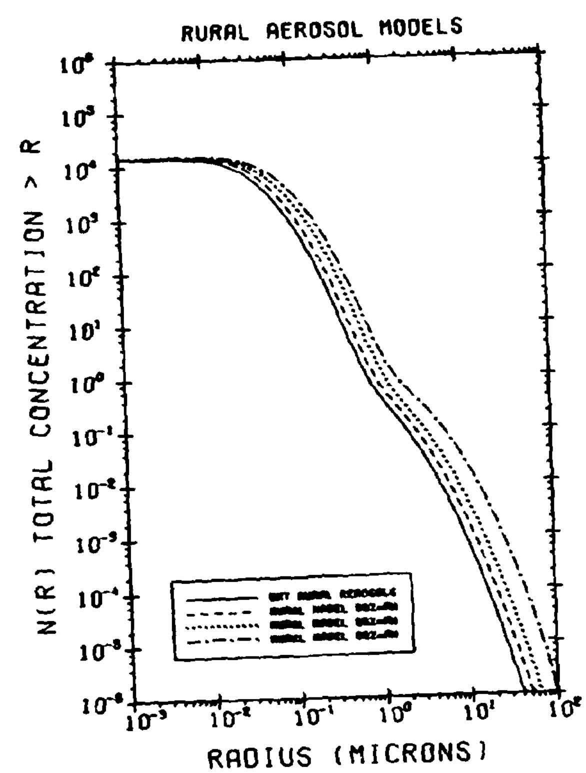

Figure 4. Cumulative Number Density (cm^{-3}) for the Rural Aerosol Model at Different Relative Humidities With Total Particle Concentration Fixed at 15,000 cm^{-3}

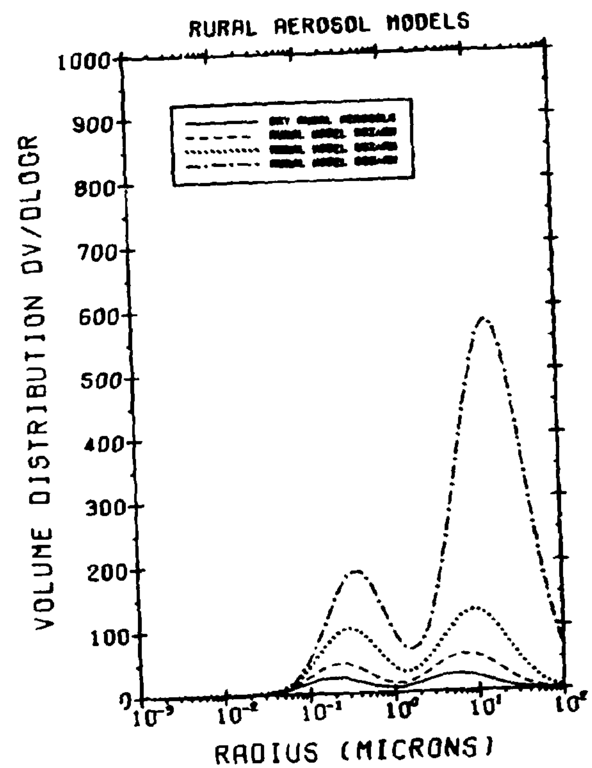

Figure 5. Volume Distribution ($\mu m^3/cm^3$) for the Rural Aerosol Model at Different Relative Humidities With the Total Particle Concentration Fixed at 15,000 cm^{-3}

Table 4. Refractive Index of the Rural Model as a Function of Relative Humidity and *Wavelength* (a) Small Rural Aerosols

WAVE-LENGTH	SMALL RURL RH = 0%	SMALL RURL RH =50%	SMALL RURL RH =70%	SMALL RURL RH =80%	SMALL RURL RH =90%	SMALL RURL RH =95%	SMALL RURL RH =98%	SMALL RURL RH =99%
.2000	1.530-7.00E-02	1.523-4.64E-02	1.510-5.98E-02	1.471-3.92E-02	1.441-2.35E-02	1.431-1.01E-02	1.421-1.28E-02	1.415-9.71E-03
.2500	1.530-3.00E-02	1.521-2.85E-02	1.505-2.56E-02	1.456-1.60E-02	1.418-1.01E-02	1.405-7.76E-03	1.393-5.51E-03	1.389-4.16E-03
.3000	1.530-8.00E-03	1.521-7.59E-03	1.504-6.03E-03	1.450-4.49E-03	1.410-2.69E-03	1.396-2.07E-03	1.382-1.47E-03	1.374-1.11E-03
.3371	1.530-5.90E-03	1.520-5.60E-03	1.503-5.04E-03	1.449-3.31E-03	1.407-1.90E-03	1.393-1.53E-03	1.379-1.08E-03	1.371-8.19E-04
.4000	1.530-5.90E-03	1.520-5.60E-03	1.502-5.04E-03	1.446-3.31E-03	1.403-1.90E-03	1.388-1.53E-03	1.374-1.08E-03	1.366-8.19E-04
.4880	1.530-5.90E-03	1.520-5.60E-03	1.502-5.04E-03	1.444-3.31E-03	1.401-1.90E-03	1.385-1.53E-03	1.371-1.08E-03	1.362-8.19E-04
.5145	1.530-5.90E-03	1.520-5.60E-03	1.501-5.04E-03	1.444-3.31E-03	1.400-1.90E-03	1.385-1.53E-03	1.370-1.08E-03	1.361-8.19E-04
.5500	1.530-6.60E-03	1.520-6.26E-03	1.501-5.63E-03	1.443-3.70E-03	1.399-2.22E-03	1.384-1.71E-03	1.369-1.21E-03	1.360-9.16E-04
.6328	1.530-6.60E-03	1.520-6.26E-03	1.501-5.63E-03	1.443-3.70E-03	1.399-2.22E-03	1.383-1.71E-03	1.368-1.21E-03	1.359-9.16E-04
.6943	1.530-7.30E-03	1.520-6.92E-03	1.501-6.23E-03	1.443-4.09E-03	1.398-2.45E-03	1.382-1.89E-03	1.368-1.34E-03	1.359-1.01E-03
.8600	1.520-1.00E-02	1.510-1.02E-02	1.492-9.22E-03	1.436-6.06E-03	1.393-3.63E-03	1.378-2.79E-03	1.364-1.90E-03	1.356-1.50E-03
1.0600	1.520-1.43E-02	1.510-1.36E-02	1.492-1.22E-02	1.435-8.02E-03	1.391-4.01E-03	1.376-3.70E-03	1.362-2.63E-03	1.353-1.99E-03
1.3000	1.495-1.64E-02	1.486-1.56E-02	1.470-1.40E-02	1.419-9.21E-03	1.381-5.53E-03	1.367-4.27E-03	1.355-3.14E-03	1.347-2.31E-03
1.5360	1.477-1.05E-02	1.469-1.76E-02	1.454-1.50E-02	1.407-1.04E-02	1.371-6.20E-03	1.359-4.86E-03	1.347-3.48E-03	1.340-2.65E-03
1.8000	1.421-1.43E-02	1.415-1.36E-02	1.405-1.22E-02	1.373-8.07E-03	1.345-4.88E-03	1.340-3.70E-03	1.332-2.72E-03	1.327-2.08E-03
2.0000	1.372-8.00E-03	1.369-7.65E-03	1.382-6.99E-03	1.343-4.97E-03	1.328-3.42E-03	1.323-2.88E-03	1.318-2.37E-03	1.315-2.06E-03
2.2500	1.360-9.70E-03	1.357-9.22E-03	1.358-8.34E-03	1.333-5.61E-03	1.315-3.52E-03	1.310-2.80E-03	1.304-7.18E-03	1.301-1.60E-03
2.5000	1.340-1.11E-02	1.344-1.06E-02	1.335-9.73E-03	1.310-6.99E-03	1.290-4.89E-03	1.283-4.16E-03	1.277-3.46E-03	1.273-3.04E-03
2.7300	1.334-4.24E-02	1.326-4.12E-02	1.313-3.90E-02	1.270-3.21E-02	1.237-2.69E-02	1.226-2.54E-02	1.215-2.33E-02	1.200-2.22E-02
3.0000	1.342-1.90E-02	1.343-3.20E-02	1.346-5.63E-02	1.155 -.130	1.361 -.187	1.364 -.207	1.366 -.226	1.367 -.237
3.2000	1.367-8.60E-03	1.373-1.19E-02	1.383-2.09E-02	1.416-4.54E-02	1.441-6.42E-02	1.449-7.07E-02	1.450-7.70E-02	1.463-8.08E-02
3.3923	1.379-8.80E-03	1.381-8.40E-03	1.385-1.35E-02	1.398-1.39E-02	1.408-1.65E-02	1.411-1.74E-02	1.414-1.83E-02	1.416-1.80E-02
3.5000	1.399-6.00E-03	1.399-6.93E-03	1.399-7.10E-03	1.399-7.94E-03	1.400-8.53E-03	1.408-8.73E-03	1.406-8.92E-03	1.400-9.04E-03
3.7500	1.397-6.10E-03	1.396-6.97E-03	1.393-5.72E-03	1.385-4.96E-03	1.379-4.37E-03	1.376-4.17E-03	1.374-3.90E-03	1.373-3.86E-03
4.0000	1.397-7.10E-03	1.394-6.97E-03	1.390-6.73E-03	1.377-6.04E-03	1.366-5.44E-03	1.363-5.25E-03	1.359-5.06E-03	1.357-4.95E-03
4.5300	1.400-1.33E-02	1.397-1.33E-02	1.390-1.33E-02	1.377-1.33E-02	1.359-1.34E-02	1.350-1.34E-02	1.344-1.34E-02	1.341-1.34E-02
5.0000	1.390-1.32E-02	1.387-1.32E-02	1.380-1.31E-02	1.361-1.29E-02	1.347-1.27E-02	1.342-1.26E-02	1.337-1.25E-02	1.334-1.25E-02
5.5900	1.374-1.09E-02	1.370-1.85E-02	1.367-1.70E-02	1.341-1.57E-02	1.324-1.41E-02	1.318-1.35E-02	1.312-1.29E-02	1.309-1.26E-02
6.0000	1.332-2.72E-02	1.329-3.13E-02	1.322-3.09E-02	1.303-6.27E-02	1.288-8.42E-02	1.282-8.64E-02	1.277-9.24E-02	1.274-9.59E-02
6.2000	1.343-3.06E-20	1.344-3.76E-02	1.346-3.99E-02	1.352-5.58E-02	1.356-6.07E-02	1.358-7.32E-02	1.359-7.75E-02	1.360-8.06E-02
6.5300	1.361-3.57E-02	1.360-3.59E-02	1.358-3.62E-02	1.351-3.72E-02	1.346-3.80E-02	1.345-3.83E-02	1.343-3.86E-02	1.342-3.87E-02
7.2300	1.400-6.55E-02	1.395-4.38E-02	1.387-6.06E-02	1.361-5.08E-02	1.342-4.33E-02	1.335-4.07E-02	1.326-3.82E-02	1.324-3.67E-02
7.9890	1.105-5.75E-02	1.191-5.63E-02	1.201-5.49E-02	1.233-4.71E-02	1.257-4.18E-02	1.266-4.00E-02	1.274-3.82E-02	1.279-3.72E-02
8.2900	1.046-9.22E-02	1.050-8.93E-02	1.081-8.39E-02	1.151-6.71E-02	1.265-5.43E-02	1.224-4.99E-02	1.247-4.56E-02	1.253-4.30E-02
8.5000	1.300 -.178	1.299 -.170	1.297 -.157	1.290 -.116	1.285-8.40E-02	1.284-7.31E-02	1.282-6.25E-02	1.281-5.62E-02
8.7000	2.100 -.233	2.057 -.223	1.979 -.204	1.736 -.147	1.550 -.103	1.488-8.83E-02	1.424-7.37E-02	1.387-6.49E-02
9.0000	2.302 -.301	2.249 -.208	2.150 -.263	1.845 -.186	1.611 -.128	1.531 -.107	1.453-8.70E-02	1.406-7.61E-02
9.2000	2.056 -.339	2.015 -.324	1.939 -.295	1.704 -.208	1.524 -.141	1.467 -.118	1.402-9.61E-02	1.366-8.20E-02
9.5000	1.884 -.161	1.851 -.155	1.790 -.144	1.662 -.110	1.458-8.34E-02	1.465-7.44E-02	1.361-6.57E-02	1.332-6.85E-02
9.8300	1.831 -.115	1.800 -.112	1.743 -.105	1.567-8.56E-02	1.431-7.05E-02	1.385-6.53E-02	1.339-6.02E-02	1.313-5.72E-02
10.0300	1.799 -.112	1.769 -.100	1.714 -.103	1.544-8.49E-02	1.413-7.12E-02	1.348-6.65E-02	1.325-6.28E-02	1.299-5.92E-02
10.5910	1.710-8.50E-02	1.698-8.41E-02	1.639-8.24E-02	1.401-7.73E-02	1.360-7.33E-02	1.318-7.20E-02	1.270-7.66E-02	1.254-6.99E-02
11.0000	1.690-6.65E-02	1.662-6.81E-02	1.631-7.09E-02	1.456-7.98E-02	1.333-8.66E-02	1.292-8.90E-02	1.252-9.12E-02	1.228-9.26E-02
11.5000	1.646-6.29E-02	1.619-6.70E-02	1.570-7.45E-02	1.418-9.76E-02	1.301 -.115	1.260 -.122	1.221 -.127	1.198 -.131
12.5000	1.587-6.41E-02	1.563-7.41E-02	1.519-9.26E-02	1.383 -.150	1.279 -.194	1.243 -.209	1.208 -.223	1.187 -.232
13.0000	1.575-6.85E-02	1.553-8.07E-02	1.512 -.103	1.387 -.172	1.290 -.226	1.257 -.244	1.225 -.262	1.206 -.272
14.0000	1.548-7.66E-02	1.531-9.17E-02	1.499 -.120	1.400 -.205	1.324 -.271	1.297 -.294	1.272 -.316	1.257 -.329
14.8000	1.479 -.100	1.468 -.115	1.447 -.143	1.382 -.230	1.332 -.297	1.315 -.320	1.299 -.342	1.289 -.355
15.0000	1.465 -.170	1.455 -.182	1.436 -.204	1.379 -.272	1.338 -.324	1.320 -.342	1.306 -.359	1.297 -.370
16.4000	1.785 -.142	1.687 -.157	1.653 -.184	1.547 -.267	1.467 -.331	1.439 -.353	1.412 -.375	1.396 -.387
17.2000	1.945 -.190	1.916 -.210	1.863 -.232	1.699 -.299	1.574 -.351	1.531 -.369	1.489 -.387	1.464 -.397
18.0000	1.870 -.161	1.855 -.174	1.831 -.199	1.679 -.277	1.578 -.337	1.541 -.357	1.507 -.377	1.486 -.389
18.5000	1.787 -.155	1.769 -.169	1.737 -.194	1.636 -.272	1.559 -.332	1.532 -.352	1.506 -.372	1.491 -.384
20.0000	1.980 -.220	1.962 -.229	1.914 -.245	1.765 -.296	1.651 -.335	1.611 -.348	1.573 -.361	1.550 -.369
21.3000	1.973 -.245	1.940 -.252	1.903 -.265	1.761 -.304	1.653 -.334	1.616 -.345	1.579 -.355	1.558 -.361
22.5000	1.970 -.252	1.946 -.258	1.902 -.269	1.766 -.304	1.662 -.330	1.626 -.339	1.591 -.340	1.570 -.354
25.0000	1.907 -.260	1.888 -.273	1.852 -.281	1.742 -.307	1.657 -.326	1.628 -.333	1.664 -.341	1.583 -.344
27.9300	1.855 -.299	1.839 -.301	1.810 -.305	1.721 -.316	1.652 -.325	1.628 -.328	1.605 -.331	1.591 -.333
30.0000	1.814 -.336	1.800 -.336	1.776 -.335	1.690 -.332	1.639 -.331	1.619 -.330	1.599 -.329	1.587 -.329
35.0000	1.914 -.430	1.894 -.425	1.850 -.416	1.746 -.389	1.660 -.368	1.631 -.360	1.602 -.353	1.585 -.349
40.0000	1.932 -.530	1.911 -.523	1.872 -.509	1.751 -.466	1.658 -.434	1.626 -.422	1.595 -.412	1.576 -.405

Table 4. Refractive Index of the Rural Model as a Function of Relative Humidity and Wavelength, (b) Large Rural Aerosols

WAVE-LENGTH	LARGE RURL RH = 0%	LARGE RURL RH = 50%	LARGE RURL RH = 70%	LARGE RURL RH = 80%	LARGE RURL RH = 90%	LARGE RURL RH = 95%	LARGE RURL RH = 98%	LARGE RURL RH = 99%
.2000	1.530-7.00E-02	1.523-6.64E-02	1.508-5.83E-02	1.461-3.39E-02	1.435-2.06E-02	1.426-1.57E-02	1.400-6.64E-03	1.403-3.63E-03
.2500	1.530-3.00E-02	1.521-2.84E-02	1.502-2.50E-02	1.443-1.45E-02	1.411-8.84E-03	1.400-6.73E-03	1.377-2.59E-03	1.370-1.47E-03
.3000	1.530-8.60E-03	1.521-7.59E-03	1.508-6.66E-03	1.437-3.87E-03	1.402-2.36E-03	1.390-1.79E-03	1.365-6.91E-04	1.350-3.92E-04
.3371	1.530-5.90E-03	1.520-5.59E-03	1.499-4.91E-03	1.435-2.86E-03	1.400-1.74E-03	1.386-1.32E-03	1.361-5.09E-04	1.354-2.89E-04
.4000	1.530-5.90E-03	1.520-5.59E-03	1.498-4.91E-03	1.431-2.86E-03	1.395-1.74E-03	1.382-1.32E-03	1.355-5.09E-04	1.348-2.89E-04
.4880	1.530-5.90E-03	1.520-5.59E-03	1.497-4.91E-03	1.429-2.86E-03	1.392-1.74E-03	1.379-1.32E-03	1.352-5.09E-04	1.345-2.89E-04
.5145	1.530-5.90E-03	1.520-5.59E-03	1.497-4.91E-03	1.429-2.86E-03	1.392-1.74E-03	1.378-1.32E-03	1.351-5.09E-04	1.344-2.89E-04
.5500	1.530-6.60E-03	1.520-6.26E-03	1.497-5.49E-03	1.420-3.19E-03	1.391-1.94E-03	1.377-1.48E-03	1.350-5.70E-04	1.343-3.23E-04
.6328	1.530-6.60E-03	1.520-6.26E-03	1.497-5.49E-03	1.420-3.19E-03	1.390-1.94E-03	1.376-1.48E-03	1.349-5.70E-04	1.342-3.23E-04
.6943	1.530-7.30E-03	1.520-6.92E-03	1.497-6.08E-03	1.427-3.53E-03	1.390-2.15E-03	1.376-1.64E-03	1.348-6.30E-04	1.341-3.57E-04
.8600	1.520-1.00E-02	1.510-1.02E-02	1.488-8.99E-03	1.421-5.23E-03	1.385-3.10E-03	1.372-2.42E-03	1.345-9.33E-04	1.338-5.29E-04
1.0600	1.520-1.43E-02	1.510-1.36E-02	1.487-1.19E-02	1.420-6.92E-03	1.383-4.22E-03	1.369-3.21E-03	1.343-1.24E-03	1.335-7.04E-04
1.3000	1.495-1.64E-02	1.486-1.56E-02	1.466-1.37E-02	1.406-7.96E-03	1.374-4.86E-03	1.362-3.71E-03	1.338-1.45E-03	1.331-8.38E-04
1.5360	1.477-1.85E-02	1.469-1.75E-02	1.450-1.54E-02	1.395-9.01E-03	1.365-5.52E-03	1.354-4.23E-03	1.332-1.69E-03	1.326-1.08E-03
1.8000	1.421-1.43E-02	1.415-1.36E-02	1.403-1.19E-02	1.365-6.92E-03	1.344-4.29E-03	1.336-3.30E-03	1.321-1.34E-03	1.317-8.09E-04
2.0000	1.372-8.00E-03	1.369-7.64E-03	1.361-6.94E-03	1.339-4.44E-03	1.325-3.13E-03	1.321-2.65E-03	1.312-1.73E-03	1.309-1.44E-03
2.2500	1.363-9.70E-03	1.356-9.22E-03	1.349-8.14E-03	1.325-4.96E-03	1.312-3.13E-03	1.307-2.48E-03	1.290-1.19E-03	1.295-8.48E-04
2.5000	1.340-1.11E-02	1.343-1.06E-02	1.333-9.53E-03	1.303-6.27E-03	1.287-4.50E-03	1.281-3.84E-03	1.269-2.55E-03	1.265-2.26E-03
2.7000	1.334-4.24E-02	1.326-4.12E-02	1.310-3.85E-02	1.259-3.03E-02	1.231-2.59E-02	1.221-2.42E-02	1.281-2.16E-02	1.195-2.01E-02
3.0000	1.342-1.90E-02	1.344-2.21E-02	1.347-6.14E-02	1.357 -.153	1.362 -.197	1.364 -.215	1.368 -.250	1.370 -.260
3.2000	1.367-8.60E-03	1.373-1.29E-02	1.386-2.26E-02	1.424-5.10E-02	1.445-6.77E-02	1.453-7.36E-02	1.460-8.52E-02	1.473-8.83E-02
3.3923	1.379-8.00E-03	1.381-9.40E-03	1.386-1.07E-02	1.401-1.40E-02	1.409-1.70E-02	1.412-1.70E-02	1.410-1.94E-02	1.420-1.90E-02
3.5000	1.399-6.80E-03	1.399-6.93E-03	1.399-7.24E-03	1.400-8.14E-03	1.446-8.63E-03	1.406-8.82E-03	1.446-9.10E-03	1.400-9.27E-03
3.7500	1.397-6.10E-03	1.396-5.97E-03	1.393-5.66E-03	1.383-4.76E-03	1.377-4.27E-03	1.375-4.00E-03	1.371-3.72E-03	1.370-3.63E-03
4.0000	1.397-7.10E-03	1.394-6.97E-03	1.389-6.60E-03	1.373-5.81E-03	1.364-5.34E-03	1.361-5.16E-03	1.355-4.82E-03	1.353-4.72E-03
4.5000	1.400-1.33E-02	1.396-1.33E-02	1.389-1.33E-02	1.365-1.34E-02	1.352-1.34E-02	1.347-1.34E-02	1.338-1.34E-02	1.335-1.34E-02
5.0000	1.390-1.32E-02	1.387-1.32E-02	1.379-1.31E-02	1.356-1.28E-02	1.344-1.26E-02	1.340-1.26E-02	1.331-1.25E-02	1.320-1.24E-02
5.5000	1.374-1.09E-02	1.370-1.05E-02	1.361-1.77E-02	1.335-1.51E-02	1.328-1.39E-02	1.315-1.32E-02	1.305-1.22E-02	1.302-1.20E-02
6.0000	1.332-2.72E-02	1.329-3.13E-02	1.321-4.06E-02	1.297-6.84E-02	1.285-8.35E-02	1.260-8.91E-02	1.271 -.100	1.260 -.103
6.2000	1.343-3.06E-02	1.344-3.36E-02	1.346-4.02E-02	1.351-6.02E-02	1.357-7.11E-02	1.359-7.51E-02	1.361-8.30E-02	1.362-8.52E-02
6.5000	1.361-3.57E-02	1.360-3.59E-02	1.357-3.63E-02	1.350-3.75E-02	1.345-3.82E-02	1.344-3.84E-02	1.341-3.89E-02	1.340-3.90E-02
7.2000	1.400-6.55E-02	1.395-6.30E-02	1.385-5.99E-02	1.355-4.83E-02	1.338-4.19E-02	1.332-3.96E-02	1.324-3.54E-02	1.316-3.37E-02
7.9000	1.105-5.75E-02	1.191-5.63E-02	1.263-5.35E-02	1.241-4.52E-02	1.262-4.09E-02	1.276-3.92E-02	1.285-3.59E-02	1.289-3.51E-02
8.2000	1.046-9.22E-02	1.058-8.92E-02	1.086-8.26E-02	1.170-6.27E-02	1.215-5.19E-02	1.232-4.79E-02	1.265-4.00E-02	1.274-3.79E-02
8.5000	1.300 -.178	1.299 -.170	1.296 -.154	1.289 -.165	1.284-7.81E-02	1.283-6.82E-02	1.280-4.84E-02	1.279-4.35E-02
8.7000	2.100 -.233	2.357 -.222	1.961 -.230	1.673 -.132	1.516-9.53E-02	1.450-8.16E-02	1.344-5.47E-02	1.313-4.74E-02
9.0000	2.302 -.301	2.248 -.287	2.120 -.257	1.765 -.166	1.560 -.117	1.495-9.84E-02	1.352-6.24E-02	1.313-5.27E-02
9.2000	2.056 -.339	2.015 -.324	1.922 -.299	1.643 -.185	1.491 -.129	1.435 -.108	1.324-6.72E-02	1.294-5.61E-02
9.5000	1.884 -.161	1.851 -.155	1.777 -.141	1.553 -.101	1.432-7.86E-02	1.387-7.04E-02	1.290-5.44E-02	1.274-5.06E-02
9.8099	1.831 -.115	1.800 -.112	1.730 -.104	1.520-8.04E-02	1.406-6.77E-02	1.364-6.30E-02	1.281-5.37E-02	1.258-5.12E-02
10.0000	1.799 -.112	1.769 -.100	1.702 -.101	1.499-8.02E-02	1.389-6.07E-02	1.348-6.44E-02	1.260-5.61E-02	1.246-5.30E-02
10.5910	1.710-8.50E-02	1.690-8.41E-02	1.628-8.21E-02	1.440-7.59E-02	1.338-7.26E-02	1.308-7.14E-02	1.228-6.89E-02	1.205-6.83E-02
11.0000	1.698-6.65E-02	1.662-6.81E-02	1.608-7.16E-02	1.413-8.21E-02	1.311-8.79E-02	1.273-9.00E-02	1.199-9.42E-02	1.179-9.53E-02
11.5000	1.646-6.29E-02	1.619-6.70E-02	1.559-7.62E-02	1.370 -.104	1.279 -.119	1.243 -.124	1.171 -.135	1.151 -.138
12.5000	1.587-6.41E-02	1.563-7.42E-02	1.509-9.60E-02	1.348 -.165	1.260 -.202	1.227 -.215	1.163 -.242	1.146 -.249
13.0300	1.575-6.85E-02	1.553-8.07E-02	1.503 -.108	1.356 -.191	1.272 -.239	1.242 -.252	1.183 -.285	1.167 -.293
14.0000	1.540-7.66E-02	1.531-9.10E-02	1.491 -.126	1.374 -.228	1.310 -.284	1.286 -.304	1.239 -.345	1.227 -.356
14.8000	1.479 -.100	1.460 -.115	1.442 -.150	1.365 -.253	1.323 -.309	1.300 -.330	1.277 -.371	1.269 -.382
15.0000	1.465 -.170	1.455 -.182	1.432 -.209	1.366 -.290	1.327 -.334	1.314 -.350	1.287 -.382	1.280 -.391
16.4000	1.705 -.142	1.686 -.157	1.645 -.190	1.520 -.209	1.452 -.343	1.426 -.363	1.377 -.402	1.364 -.413
17.2000	1.945 -.198	1.916 -.210	1.851 -.237	1.657 -.317	1.551 -.361	1.511 -.377	1.434 -.409	1.413 -.418
18.0000	1.878 -.161	1.854 -.174	1.802 -.205	1.643 -.298	1.557 -.348	1.525 -.366	1.462 -.403	1.445 -.413
18.5000	1.787 -.155	1.769 -.169	1.729 -.200	1.689 -.292	1.544 -.343	1.520 -.361	1.473 -.390	1.460 -.468
20.0000	1.988 -.220	1.962 -.220	1.983 -.249	1.726 -.309	1.630 -.342	1.594 -.354	1.524 -.370	1.505 -.385
21.3000	1.973 -.245	1.968 -.252	1.892 -.260	1.724 -.314	1.633 -.340	1.595 -.349	1.533 -.368	1.515 -.373
22.5000	1.970 -.252	1.946 -.250	1.892 -.272	1.731 -.313	1.643 -.335	1.610 -.344	1.546 -.360	1.529 -.364
25.0000	1.907 -.260	1.888 -.273	1.844 -.283	1.713 -.313	1.642 -.330	1.615 -.336	1.563 -.348	1.549 -.352
27.9000	1.855 -.299	1.839 -.301	1.804 -.306	1.697 -.319	1.635 -.327	1.618 -.330	1.575 -.335	1.564 -.337
30.0000	1.814 -.336	1.800 -.336	1.770 -.335	1.670 -.332	1.628 -.339	1.618 -.330	1.574 -.329	1.564 -.328
35.0000	1.914 -.430	1.894 -.425	1.858 -.414	1.717 -.381	1.645 -.364	1.618 -.357	1.565 -.344	1.551 -.341
40.0000	1.932 -.530	1.911 -.522	1.863 -.596	1.719 -.455	1.641 -.428	1.612 -.418	1.555 -.390	1.539 -.392

Table 5. Refractive Index of the Urban Model as a Function of Relative Humidity and Wavelength, (a) Small Urban Aerosols

WAVE-LENGTH	SMALL URBN RH = 0%	SMALL URBN RH = 50%	SMALL URBN RH = 70%	SMALL URBN RH = 80%	SMALL URBN RH = 90%	SMALL URBN RH = 95%	SMALL URBN RH = 98%	SMALL URBN RH = 99%
.2000	1.524 -.128	1.515 -.117	1.477-7.98E-02	1.442-4.54E-02	1.423-2.60E-02	1.413-1.67E-02	1.405-9.13E-03	1.402-6.13E-03
.2500	1.540 -.114	1.535 -.106	1.480-7.22E-02	1.429-4.11E-02	1.402-2.43E-02	1.387-1.51E-02	1.375-8.26E-03	1.371-5.55E-03
.3000	1.572 -.100	1.556-9.32E-02	1.490-6.36E-02	1.429-3.62E-02	1.396-2.14E-02	1.379-1.33E-02	1.365-7.28E-03	1.360-4.89E-03
.3371	1.574-9.87E-02	1.558-9.17E-02	1.498-6.29E-02	1.427-3.56E-02	1.394-2.10E-02	1.379-1.31E-02	1.362-7.16E-03	1.356-4.88E-03
.4000	1.574-9.67E-02	1.557-8.98E-02	1.488-6.12E-02	1.424-3.48E-02	1.389-2.06E-02	1.370-1.28E-02	1.356-7.01E-03	1.350-4.71E-03
.4880	1.574-9.47E-02	1.557-8.80E-02	1.486-6.00E-02	1.421-3.41E-02	1.386-2.02E-02	1.367-1.25E-02	1.352-6.87E-03	1.347-4.61E-03
.5145	1.574-9.47E-02	1.557-8.80E-02	1.486-6.00E-02	1.420-3.41E-02	1.385-2.02E-02	1.366-1.25E-02	1.351-6.87E-03	1.346-4.61E-03
.5500	1.574-9.33E-02	1.557-8.66E-02	1.486-5.91E-02	1.420-3.36E-02	1.384-1.99E-02	1.365-1.24E-02	1.350-6.76E-03	1.345-4.54E-03
.6328	1.574-9.13E-02	1.557-8.48E-02	1.485-5.78E-02	1.419-3.29E-02	1.384-1.94E-02	1.364-1.21E-02	1.350-6.62E-03	1.344-4.44E-03
.6943	1.574-9.10E-02	1.557-8.53E-02	1.485-5.81E-02	1.419-3.31E-02	1.383-1.96E-02	1.363-1.22E-02	1.349-6.66E-03	1.343-4.47E-03
.8600	1.566-9.46E-02	1.549-8.79E-02	1.479-5.99E-02	1.414-3.41E-02	1.379-2.01E-02	1.360-1.25E-02	1.346-6.86E-03	1.341-4.61E-03
1.0600	1.560-9.94E-02	1.549-9.23E-02	1.478-6.30E-02	1.412-3.58E-02	1.377-2.12E-02	1.356-1.32E-02	1.343-7.21E-03	1.338-4.84E-03
1.3000	1.548 -.103	1.532-9.58E-02	1.465-6.53E-02	1.404-3.72E-02	1.371-2.20E-02	1.352-1.37E-02	1.339-7.51E-03	1.334-5.05E-03
1.5360	1.536 -.107	1.520-9.92E-02	1.456-6.77E-02	1.396-3.85E-02	1.364-2.28E-02	1.347-1.42E-02	1.334-7.83E-03	1.329-5.29E-03
1.8000	1.495 -.107	1.482-9.98E-02	1.420-6.81E-02	1.370-3.88E-02	1.351-2.30E-02	1.336-1.43E-02	1.325-7.89E-03	1.321-5.34E-03
2.0000	1.458 -.104	1.447-9.70E-02	1.402-6.65E-02	1.361-3.87E-02	1.338-2.31E-02	1.326-1.48E-02	1.317-8.59E-03	1.313-6.13E-03
2.2500	1.450 -.100	1.479 -.100	.392-6.84E-02	1.349-3.91E-02	1.328-2.32E-02	1.313-1.46E-02	1.303-8.17E-03	1.306-5.62E-03
2.5000	1.442 -.111	1.429 -.103	1.376-7.08E-02	1.326-4.18E-02	1.300-2.50E-02	1.285-1.62E-02	1.274-9.65E-03	1.270-7.05E-03
2.7300	1.433 -.130	1.416 -.129	1.343-9.43E-02	1.276-6.18E-02	1.248-4.43E-02	1.220-3.48E-02	1.206-2.76E-02	1.200-2.48E-02
3.0000	1.442 -.123	1.437 -.134	1.416 -.178	1.195 -.210	1.306 -.240	1.300 -.252	1.376 -.261	1.374 -.265
3.2000	1.466 -.115	1.466 -.113	1.470 -.107	1.474 -.100	1.475-9.72E-02	1.476-9.54E-02	1.477-9.48E-02	1.477-9.35E-02
3.3923	1.477 -.117	1.473 -.110	1.457-8.16E-02	1.442-5.57E-02	1.434-4.10E-02	1.429-3.32E-02	1.426-2.74E-02	1.425-2.51E-02
3.5000	1.495 -.117	1.480 -.110	1.460-7.78E-02	1.434-4.83E-02	1.420-3.24E-02	1.413-2.37E-02	1.407-1.72E-02	1.405-1.47E-02
3.7500	1.490 -.119	1.469 -.111	1.451-7.66E-02	1.415-4.51E-02	1.396-2.81E-02	1.386-1.88E-02	1.378-1.19E-02	1.375-9.12E-03
4.0300	1.501 -.122	1.490 -.113	1.446-7.87E-02	1.405-4.60E-02	1.383-2.95E-02	1.371-2.01E-02	1.362-1.31E-02	1.354-1.03E-02
4.5000	1.510 -.129	1.495 -.120	1.443-8.64E-02	1.395-5.49E-02	1.369-3.79E-02	1.359-2.07E-02	1.345-2.10E-02	1.341-1.98E-02
5.0000	1.506 -.131	1.493 -.122	1.440-8.72E-02	1.390-5.50E-02	1.364-3.76E-02	1.349-2.81E-02	1.338-2.10E-02	1.334-1.82E-02
5.5900	1.497 -.137	1.483 -.128	1.424-9.11E-02	1.378-5.68E-02	1.340-3.83E-02	1.324-2.62E-02	1.312-2.07E-02	1.308-1.77E-02
6.0900	1.470 -.146	1.455 -.143	1.395 -.132	1.339 -.121	1.305 -.115	1.292 -.112	1.280 -.110	1.275 -.109
6.2000	1.480 -.149	1.472 -.145	1.437 -.127	1.405 -.110	1.388 -.101	1.379-9.61E-02	1.372-9.25E-02	1.369-9.16E-02
6.5000	1.497 -.155	1.486 -.146	1.439 -.112	1.396-8.37E-02	1.373-6.38E-02	1.366-5.45E-02	1.356-4.76E-02	1.347-4.40E-02
7.2000	1.532 -.182	1.516 -.172	1.451 -.127	1.391-8.62E-02	1.359-6.41E-02	1.341-5.20E-02	1.328-4.36E-02	1.323-3.94E-02
7.9000	1.372 -.188	1.366 -.170	1.343 -.126	1.322-8.65E-02	1.311-6.50E-02	1.304-5.33E-02	1.300-4.45E-02	1.298-4.10E-02
8.2000	1.263 -.218	1.264 -.197	1.271 -.146	1.278-9.86E-02	1.281-7.23E-02	1.283-5.82E-02	1.284-4.78E-02	1.285-4.36E-02
8.5000	1.470 -.288	1.456 -.263	1.400 -.191	1.347 -.124	1.319-8.85E-02	1.303-6.89E-02	1.292-5.43E-02	1.287-4.85E-02
8.7300	2.112 -.324	2.052 -.304	1.804 -.219	1.575 -.141	1.451-9.89E-02	1.383-7.58E-02	1.333-5.86E-02	1.313-5.18E-02
9.0000	2.276 -.381	2.203 -.356	1.904 -.256	1.627 -.163	1.478 -.112	1.396-8.51E-02	1.335-6.46E-02	1.311-5.65E-02
9.2700	2.081 -.411	2.022 -.385	1.778 -.276	1.552 -.175	1.431 -.120	1.364-9.05E-02	1.315-6.83E-02	1.295-5.95E-02
9.5900	1.945 -.270	1.895 -.254	1.688 -.188	1.496 -.126	1.392-9.25E-02	1.336-7.43E-02	1.294-6.07E-02	1.277-5.54E-02
9.8000	1.905 -.235	1.857 -.222	1.657 -.166	1.472 -.115	1.373-8.77E-02	1.319-7.27E-02	1.278-6.15E-02	1.262-5.76E-02
10.0000	1.881 -.233	1.834 -.220	1.638 -.166	1.457 -.117	1.359-8.96E-02	1.306-7.50E-02	1.266-6.44E-02	1.250-5.97E-02
10.5910	1.818 -.214	1.773 -.204	1.584 -.160	1.409 -.120	1.315-9.86E-02	1.264-8.60E-02	1.225-7.84E-02	1.210-7.45E-02
11.0000	1.798 -.199	1.752 -.192	1.561 -.162	1.385 -.134	1.290 -.119	1.238 -.110	1.200 -.104	1.184 -.102
11.5000	1.765 -.198	1.719 -.194	1.530 -.176	1.356 -.162	1.262 -.154	1.211 -.149	1.172 -.146	1.157 -.145
12.5000	1.724 -.201	1.681 -.205	1.503 -.222	1.339 -.238	1.251 -.247	1.203 -.251	1.167 -.255	1.152 -.256
13.0000	1.716 -.207	1.675 -.214	1.507 -.243	1.351 -.270	1.267 -.284	1.222 -.292	1.187 -.298	1.174 -.300
14.0000	1.708 -.216	1.665 -.227	1.520 -.273	1.387 -.315	1.314 -.337	1.275 -.350	1.246 -.359	1.234 -.363
14.8000	1.649 -.238	1.621 -.249	1.506 -.296	1.399 -.339	1.341 -.363	1.310 -.375	1.286 -.385	1.277 -.389
15.0000	1.638 -.294	1.612 -.302	1.563 -.334	1.403 -.363	1.342 -.379	1.315 -.388	1.297 -.394	1.288 -.397
16.4000	1.836 -.276	1.801 -.286	1.656 -.331	1.522 -.372	1.450 -.395	1.411 -.407	1.382 -.416	1.370 -.419
17.2000	2.032 -.322	1.986 -.330	1.795 -.362	1.619 -.391	1.524 -.406	1.472 -.415	1.433 -.421	1.417 -.424
18.0000	1.902 -.293	1.942 -.303	1.777 -.342	1.624 -.378	1.542 -.390	1.497 -.408	1.464 -.416	1.450 -.420
18.5000	1.912 -.290	1.878 -.299	1.740 -.338	1.612 -.374	1.543 -.393	1.505 -.404	1.477 -.412	1.466 -.415
20.0000	2.088 -.346	2.037 -.349	1.860 -.363	1.696 -.376	1.608 -.383	1.560 -.387	1.524 -.390	1.509 -.391
21.3000	2.070 -.360	2.029 -.369	1.858 -.372	1.708 -.375	1.614 -.377	1.568 -.370	1.533 -.378	1.519 -.379
22.5000	2.072 -.376	2.032 -.375	1.864 -.374	1.719 -.372	1.626 -.371	1.581 -.371	1.547 -.370	1.534 -.370
25.0000	2.028 -.392	1.992 -.390	1.845 -.379	1.718 -.369	1.637 -.364	1.597 -.361	1.567 -.359	1.555 -.358
27.9000	1.992 -.421	1.968 -.415	1.829 -.391	1.709 -.368	1.643 -.356	1.608 -.350	1.581 -.345	1.571 -.343
30.0000	1.965 -.455	1.936 -.446	1.813 -.408	1.708 -.374	1.639 -.355	1.606 -.345	1.581 -.337	1.571 -.334
35.0000	2.057 -.538	2.020 -.524	1.865 -.464	1.721 -.409	1.644 -.379	1.602 -.363	1.570 -.351	1.558 -.346
40.0000	2.084 -.624	2.043 -.607	1.876 -.536	1.722 -.471	1.639 -.436	1.594 -.417	1.560 -.402	1.546 -.397

Table 5. Refractive Index of the Urban Model as a Function of Relative Humidity and Wavelength, (b) Large Urban Aerosols

WAVE-LENGTH	LARGE URBN RH = 0%	LARGE URBN RH =50%	LARGE URBN RH =70%	LARGE URBN RH =80%	LARGE URBN RH =90%	LARGE URBN RH =95%	LARGE URBN RH =98%	LARGE URBN RH =99%
.2000	1.524 -.126	1.514 -.116	1.471-7.40E-02	1.430-4.12E-02	1.419-2.29E-02	1.405-1.25E-02	1.401-5.05E-03	1.390-2.46E-03
.2500	1.540 -.114	1.523 -.105	1.471-6.69E-02	1.423-3.72E-02	1.396-2.07E-02	1.380-1.13E-02	1.369-4.57E-03	1.366-2.22E-03
.3000	1.572 -.100	1.554-9.24E-02	1.480-5.09E-02	1.422-3.29E-02	1.390-1.83E-02	1.371-9.98E-03	1.358-4.02E-03	1.353-1.96E-03
.3371	1.574-9.87E-02	1.556-9.08E-02	1.479-5.80E-02	1.420-3.23E-02	1.387-1.79E-02	1.368-9.82E-03	1.354-3.95E-03	1.349-1.93E-03
.4000	1.574-9.67E-02	1.555-8.90E-02	1.477-5.68E-02	1.416-3.16E-02	1.382-1.76E-02	1.362-9.62E-03	1.348-3.87E-03	1.344-1.89E-03
.4880	1.574-9.47E-02	1.555-8.71E-02	1.475-5.56E-02	1.413-3.10E-02	1.378-1.72E-02	1.359-9.42E-03	1.345-3.79E-03	1.340-1.85E-03
.5145	1.574-9.47E-02	1.555-8.71E-02	1.475-5.56E-02	1.413-3.10E-02	1.378-1.72E-02	1.358-9.42E-03	1.344-3.79E-03	1.339-1.85E-03
.5500	1.574-9.33E-02	1.555-8.58E-02	1.474-5.48E-02	1.412-3.05E-02	1.377-1.70E-02	1.357-9.28E-03	1.343-3.74E-03	1.338-1.82E-03
.6328	1.574-9.13E-02	1.555-8.40E-02	1.474-5.36E-02	1.411-2.99E-02	1.376-1.66E-02	1.356-9.08E-03	1.342-3.66E-03	1.337-1.78E-03
.6943	1.574-9.18E-02	1.555-8.45E-02	1.474-5.39E-02	1.411-3.00E-02	1.375-1.67E-02	1.355-9.13E-03	1.341-3.68E-03	1.336-1.79E-03
.8600	1.566-9.46E-02	1.547-8.71E-02	1.468-5.56E-02	1.407-3.10E-02	1.372-1.72E-02	1.353-9.41E-03	1.338-3.79E-03	1.334-1.85E-03
1.0600	1.566-9.94E-02	1.547-9.15E-02	1.467-5.84E-02	1.405-3.25E-02	1.370-1.81E-02	1.350-9.89E-03	1.336-3.99E-03	1.331-1.94E-03
1.3000	1.548 -.103	1.530-9.49E-02	1.455-6.06E-02	1.397-3.38E-02	1.364-1.88E-02	1.345-1.03E-02	1.332-4.17E-03	1.327-2.05E-03
1.5360	1.536 -.107	1.518-9.83E-02	1.446-6.27E-02	1.389-3.50E-02	1.358-1.95E-02	1.340-1.07E-02	1.327-4.37E-03	1.322-2.10E-03
1.8000	1.495 -.107	1.480-9.88E-02	1.419-6.31E-02	1.372-3.52E-02	1.345-1.96E-02	1.330-1.08E-02	1.319-4.41E-03	1.316-2.21E-03
2.0000	1.458 -.104	1.445-9.61E-02	1.395-6.17E-02	1.356-3.49E-02	1.334-1.99E-02	1.321-1.14E-02	1.312-5.24E-03	1.309-3.12E-03
2.2500	1.450 -.108	1.437-9.92E-02	1.385-6.34E-02	1.344-3.55E-02	1.321-1.99E-02	1.308-1.11E-02	1.298-4.69E-03	1.295-2.40E-03
2.5000	1.442 -.111	1.428 -.102	1.367-6.58E-02	1.320-3.75E-02	1.294-2.16E-02	1.279-1.26E-02	1.268-6.11E-03	1.265-3.07E-03
2.7000	1.433 -.138	1.414 -.128	1.332-8.08E-02	1.268-5.79E-02	1.233-4.06E-02	1.212-3.08E-02	1.198-2.38E-02	1.193-2.13E-02
3.0000	1.442 -.123	1.436 -.135	1.412 -.185	1.394 -.223	1.384 -.245	1.378 -.257	1.374 -.266	1.372 -.269
3.2000	1.466 -.115	1.467 -.113	1.471 -.106	1.474-9.98E-02	1.476-9.65E-02	1.477-9.46E-02	1.478-9.33E-02	1.478-9.28E-02
3.3923	1.477 -.117	1.473 -.109	1.454-7.71E-02	1.440-5.20E-02	1.432-3.86E-02	1.427-3.08E-02	1.424-2.43E-02	1.423-2.23E-02
3.5000	1.495 -.117	1.488 -.109	1.456-7.28E-02	1.431-4.48E-02	1.417-2.90E-02	1.409-2.01E-02	1.404-1.37E-02	1.402-1.15E-02
3.7500	1.498 -.119	1.478 -.110	1.445-7.12E-02	1.411-4.13E-02	1.392-2.45E-02	1.382-1.50E-02	1.374-8.12E-03	1.372-5.75E-03
4.0000	1.531 -.122	1.489 -.112	1.439-7.33E-02	1.430-4.29E-02	1.378-2.59E-02	1.366-1.62E-02	1.357-9.29E-03	1.354-6.48E-03
4.5000	1.508 -.129	1.494 -.119	1.435-8.11E-02	1.393-5.11E-02	1.364-3.44E-02	1.350-2.49E-02	1.339-1.86E-02	1.335-1.56E-02
5.0000	1.506 -.131	1.492 -.121	1.431-8.10E-02	1.384-5.11E-02	1.358-3.39E-02	1.343-2.41E-02	1.332-1.71E-02	1.329-1.47E-02
5.5000	1.497 -.137	1.481 -.127	1.415-8.53E-02	1.363-5.27E-02	1.334-3.44E-02	1.318-2.41E-02	1.306-1.66E-02	1.302-1.44E-02
6.0000	1.470 -.146	1.453 -.143	1.305 -.130	1.332 -.120	1.362 -.114	1.285 -.111	1.273 -.109	1.269 -.108
6.2000	1.488 -.149	1.471 -.145	1.432 -.124	1.401 -.108	1.384-9.92E-02	1.375-9.41E-02	1.368-9.05E-02	1.365-8.92E-02
6.5000	1.497 -.155	1.484 -.145	1.432 -.107	1.391-7.69E-02	1.368-6.02E-02	1.355-5.07E-02	1.349-4.30E-02	1.342-4.15E-02
7.2000	1.532 -.182	1.514 -.170	1.441 -.120	1.384-8.13E-02	1.352-5.94E-02	1.334-4.70E-02	1.321-3.81E-02	1.316-3.50E-02
7.9000	1.372 -.180	1.366 -.168	1.340 -.123	1.320-8.17E-02	1.308-6.05E-02	1.302-4.84E-02	1.297-3.98E-02	1.296-3.60E-02
8.2000	1.263 -.210	1.265 -.196	1.272 -.138	1.278-9.22E-02	1.282-6.69E-02	1.284-5.25E-02	1.285-4.21E-02	1.286-3.85E-02
8.5000	1.470 -.280	1.455 -.261	1.391 -.180	1.341 -.116	1.313-8.09E-02	1.297-6.08E-02	1.286-4.64E-02	1.282-4.14E-02
8.7000	2.112 -.324	2.045 -.301	1.765 -.206	1.547 -.132	1.425-8.99E-02	1.356-6.63E-02	1.306-4.93E-02	1.288-4.34E-02
9.0000	2.276 -.381	2.194 -.354	1.857 -.240	1.594 -.151	1.446 -.102	1.363-7.30E-02	1.303-5.36E-02	1.282-4.66E-02
9.2000	2.091 -.411	2.015 -.382	1.740 -.259	1.525 -.162	1.405 -.109	1.337-7.83E-02	1.288-5.63E-02	1.271-4.87E-02
9.5000	1.945 -.270	1.889 -.252	1.655 -.177	1.473 -.118	1.371-8.55E-02	1.313-6.68E-02	1.271-5.34E-02	1.257-4.88E-02
9.8000	1.905 -.235	1.851 -.220	1.626 -.158	1.450 -.109	1.352-8.19E-02	1.296-6.65E-02	1.256-5.54E-02	1.242-5.16E-02
10.0000	1.881 -.233	1.828 -.219	1.607 -.158	1.435 -.111	1.339-8.40E-02	1.284-6.89E-02	1.245-5.81E-02	1.231-5.44E-02
10.5910	1.810 -.214	1.767 -.202	1.554 -.153	1.388 -.115	1.295-9.41E-02	1.243-8.20E-02	1.205-7.33E-02	1.191-7.03E-02
11.0000	1.798 -.199	1.746 -.191	1.532 -.157	1.364 -.130	1.270 -.115	1.217 -.107	1.179 -.101	1.166-9.88E-02
11.5000	1.765 -.190	1.714 -.194	1.501 -.175	1.335 -.160	1.242 -.152	1.190 -.148	1.152 -.144	1.130 -.143
12.5000	1.724 -.201	1.676 -.206	1.476 -.225	1.320 -.246	1.232 -.249	1.133 -.253	1.147 -.257	1.135 -.250
13.0000	1.716 -.207	1.670 -.215	1.481 -.247	1.333 -.273	1.258 -.287	1.203 -.295	1.169 -.331	1.157 -.303
14.0000	1.788 -.216	1.661 -.229	1.498 -.280	1.370 -.320	1.299 -.342	1.259 -.355	1.230 -.364	1.220 -.367
14.8000	1.649 -.238	1.610 -.251	1.408 -.303	1.386 -.365	1.329 -.368	1.297 -.381	1.274 -.390	1.266 -.393
15.0000	1.630 -.294	1.669 -.303	1.406 -.339	1.398 -.367	1.337 -.382	1.367 -.391	1.285 -.398	1.277 -.408
16.4000	1.836 -.276	1.797 -.280	1.634 -.318	1.506 -.377	1.435 -.399	1.395 -.412	1.366 -.421	1.356 -.424
17.2000	2.032 -.322	1.980 -.331	1.765 -.366	1.597 -.394	1.503 -.410	1.458 -.418	1.412 -.425	1.399 -.427
18.0000	1.982 -.293	1.938 -.304	1.751 -.340	1.606 -.383	1.525 -.402	1.475 -.413	1.445 -.421	1.434 -.423
18.5000	1.912 -.298	1.874 -.300	1.718 -.344	1.596 -.378	1.528 -.397	1.498 -.408	1.462 -.416	1.452 -.418
20.0000	2.000 -.346	2.032 -.358	1.832 -.365	1.676 -.378	1.509 -.384	1.540 -.388	1.504 -.391	1.492 -.392
21.3000	2.070 -.368	2.024 -.369	1.831 -.373	1.681 -.376	1.596 -.377	1.549 -.378	1.514 -.379	1.502 -.379
22.5000	2.072 -.376	2.027 -.375	1.838 -.373	1.691 -.372	1.609 -.371	1.562 -.371	1.529 -.370	1.517 -.370
25.0000	2.028 -.392	1.988 -.389	1.823 -.377	1.693 -.368	1.621 -.363	1.580 -.360	1.551 -.357	1.541 -.357
27.9000	1.992 -.421	1.957 -.415	1.809 -.387	1.694 -.366	1.628 -.354	1.593 -.347	1.567 -.342	1.558 -.340
30.0000	1.965 -.455	1.932 -.445	1.794 -.402	1.687 -.369	1.626 -.351	1.592 -.341	1.568 -.333	1.559 -.336
35.0000	2.057 -.538	2.015 -.522	1.840 -.455	1.704 -.462	1.627 -.373	1.584 -.356	1.553 -.344	1.542 -.340
40.0000	2.084 -.624	2.038 -.605	1.850 -.525	1.704 -.463	1.622 -.428	1.575 -.409	1.542 -.395	1.530 -.390

2.5 Maritime Aerosol Model

The aerosol compositions and distributions of oceanic origin are significantly different from continental aerosol types. These aerosols are largely sea-salt particles which are produced by the evaporation of sea-spray droplets and then have grown again due to aggregation of water under high relative humidity conditions. However, even over the ocean there is a more or less pronounced continental aerosol background, which, mixed with the aerosols of oceanic origin, forms a fairly uniform maritime aerosol that is representative for the boundary layer in the lower 2-3 km in the atmosphere over the oceans but that also may occur over the continents in a maritime air mass. This maritime model should be distinguished from the fresh sea-spray aerosol which exists in the lower 10-20 m above the ocean surface and which is strongly dependent on wind speed.

The maritime aerosol model therefore, has been composed of two components: the sea-salt component; and a continental component which was assumed to be identical to the rural aerosol with the exception that the very large particles were eliminated since they will eventually be lost due to fallout as the air masses move across the oceans. This model is similar to the one suggested by Junge[42,48] based on his measurements.[49,50] It is also supported by the measurements made by Meszaros and Vissy[20] in the South Atlantic and Indian Oceans. They found that the larger particles had a predominantly cubic crystalline structure characteristic of sodium chloride and that the other major constituents were of other crystal types. The smallest particles were a mixture of other aerosol types—the most common identifiable component being ammonium sulphate.

For the size distribution of the oceanic component, a log normal distribution is used with $r_o = 0.3$ for moderate relative humidities ($\approx$ 80 percent) and $\sigma = 0.4$. This is consistent with the measurements of Woodcock[51] as well as the more recent measurements of Junge and Jaenicke[50] and the sea-salt type component of the data of Meszaros and Vissy.[20] The relative proportions of aerosols of oceanic or continental origins will vary particularly in coastal regions. To account for these variations, the model permits the user to adjust the relative amounts of the oceanic and continental types of aerosol. The size distribution used for the results here has 1 percent of the total number of particles of oceanic origin. The change of particle size with relative humidity is based on Hänel's[28] results for a sea-spray aerosol (his Model 2). This number density distribution is shown in Figure 6, with the corresponding cumulative number distribution and volume distributions shown in Figures 7 and 8.

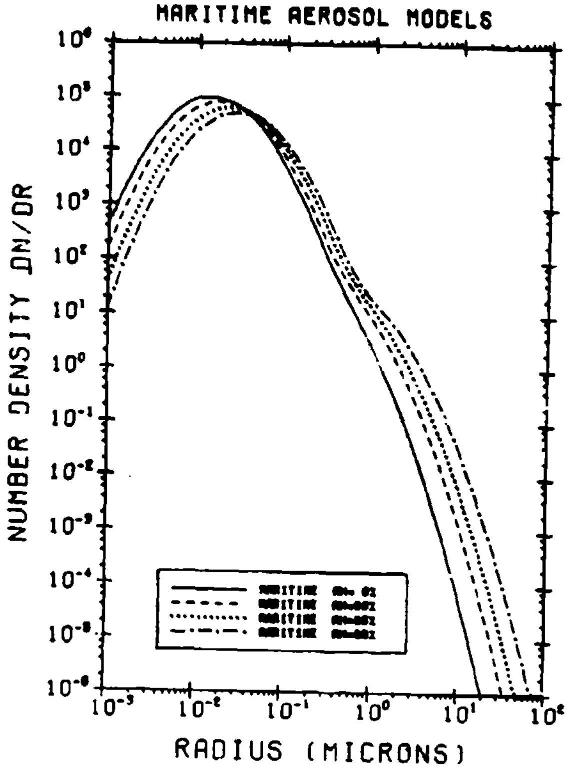

Figure 6. Aerosol Number Distribution (cm^{-3} μm^{-1}) for the Maritime Model at Different Relative Humidities With the Total Particle Concentration Fixed at 4000 cm^{-3}

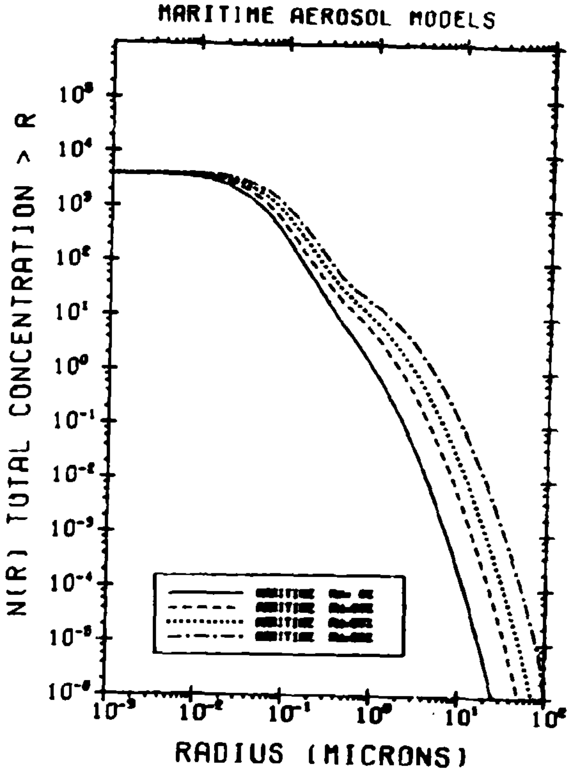

Figure 7. Cumulative Number Density (cm^{-3}) for the Maritime Aerosol Model at Different Relative Humidities With the Total Particle Concentration Fixed at 4000 cm^{-3}

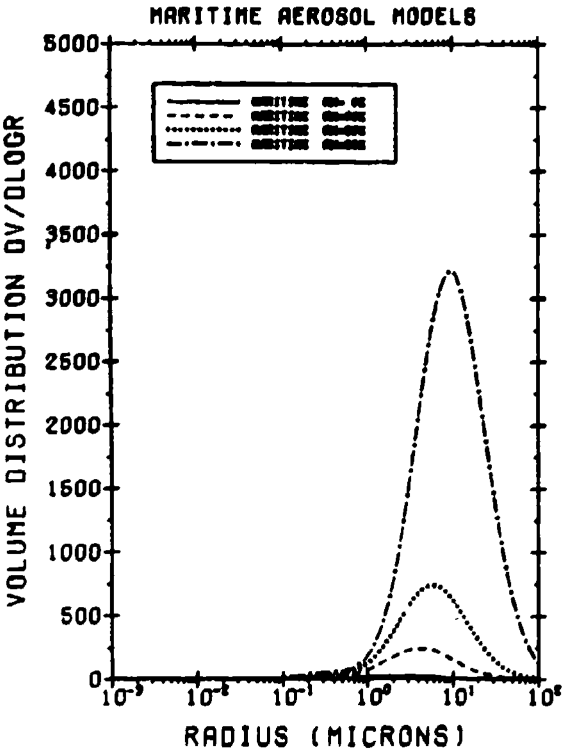

Figure 8. Volume Distribution ($\mu m^3/cm^3$) for the Maritime Aerosol Model at Different Relative Humidities With the Total Particle Concentration Fixed at 4000 cm^{-3}

The refractive index is based on that for a solution of sea salt in water, using a weighted average of the refractive indexes of water and sea salt. The relative weighting as a function of the relative humidity is based on Eq. (6). The refractive index of the sea salt is primarily taken from the measurements of Volz.[52] His data for the imaginary part were limited to wavelengths longer than 2.5 μ m, but this was extended to 0.2 μ m by using the difference between absorption measurements for sea water and pure water compiled by Dorsey[53] (Table 6).

A similar two-component maritime aerosol model has been developed by Wells et al[54] based on the earlier models of Barnhardt and Street[55] and Hodges[56]. They also have components representing aerosols of continental and marine origin. However their size distributions differ from the present models; they use more simplified refractive index models, and the treatment of humidity neglects the dependence of the relative humidity effects on either the size or composition of the aerosol.

Table 6. Refractive Index of the Oceanic Model as a Function of Relative Humidity and Wavelength

WAVE-LENGTH	OCEANIC RH = 0%	OCEANIC RH = 50%	OCEANIC RH = 70%	OCEANIC RH = 80%	OCEANIC RH = 90%	OCEANIC RH = 95%	OCEANIC RH = 98%	OCEANIC RH = 99%
.2000	1.510-1.00E-04	1.469-9.19E-05	1.452-4.02E-05	1.411-3.26E-05	1.404-7.59E-06	1.401-4.38E-06	1.390-1.94E-06	1.387-1.68E-06
.2500	1.510-5.00E-06	1.423-4.10E-06	1.433-2.43E-06	1.381-6.66E-07	1.373-4.83E-07	1.360-2.42E-07	1.365-1.27E-07	1.363-4.16E-08
.3000	1.510-2.00E-06	1.431-1.64E-06	1.427-9.72E-07	1.369-2.69E-07	1.361-1.64E-07	1.356-9.91E-08	1.352-5.32E-08	1.351-3.52E-08
.3371	1.510-4.00E-07	1.430-5.29E-07	1.425-4.97E-07	1.366-5.03E-08	1.357-3.70E-08	1.352-2.49E-08	1.348-1.50E-08	1.347-1.28E-08
.4000	1.500-3.00E-09	1.471-7.49E-09	1.417-1.54E-08	1.359-5.44E-09	1.351-3.96E-09	1.346-3.04E-09	1.342-2.39E-09	1.341-2.13E-09
.4880	1.500-2.00E-09	1.470-1.65E-08	1.415-1.01E-08	1.356-3.39E-09	1.347-2.39E-09	1.342-1.77E-09	1.338-1.33E-09	1.337-1.19E-09
.5145	1.500-1.00E-09	1.470-2.40E-09	1.414-5.43E-09	1.355-2.30E-09	1.344-1.83E-09	1.341-1.54E-09	1.337-1.34E-09	1.336-1.20E-09
.5500	1.500-1.00E-09	1.470-9.54E-09	1.413-5.03E-09	1.354-2.98E-09	1.345-2.54E-09	1.340-2.30E-09	1.336-2.11E-09	1.335-2.04E-09
.6328	1.490-2.00E-08	1.461-1.90E-08	1.400-1.72E-08	1.357-1.57E-08	1.344-1.50E-08	1.339-1.49E-08	1.335-1.47E-08	1.334-1.47E-08
.6943	1.490-1.10E-07	1.461-4.70E-08	1.400-4.40E-08	1.351-3.94E-08	1.343-3.57E-08	1.338-3.34E-08	1.334-3.18E-08	1.333-3.12E-08
.8600	1.480-3.20E-06	1.453-7.52E-06	1.402-1.62E-06	1.340-6.69E-07	1.340-5.20E-07	1.335-4.41E-07	1.332-3.79E-07	1.331-3.55E-07
1.0600	1.472-2.00E-04	1.444-3.64E-04	1.395-9.95E-05	1.344-2.91E-05	1.337-1.00E-05	1.332-1.26E-05	1.329-7.09E-06	1.327-6.00E-06
1.3000	1.470-4.80E-04	1.443-7.01E-04	1.390-1.93E-04	1.342-7.01E-05	1.334-6.19E-05	1.329-5.05E-05	1.326-4.30E-05	1.324-4.01E-05
1.5360	1.463-6.00E-04	1.434-7.09E-04	1.386-3.41E-04	1.336-1.63E-04	1.329-1.37E-04	1.324-1.21E-04	1.321-1.69E-04	1.319-1.34E-04
1.8000	1.450-8.00E-04	1.425-4.76E-04	1.379-4.45E-04	1.330-2.02E-04	1.322-1.64E-04	1.310-1.44E-04	1.315-1.20E-04	1.313-1.22E-04
2.0000	1.450-1.00E-03	1.424-1.82E-03	1.375-1.09E-03	1.326-1.09E-03	1.317-1.09E-03	1.312-1.10E-03	1.309-1.10E-03	1.307-1.10E-03
2.2500	1.440-2.00E-03	1.413-1.71E-03	1.363-1.17E-03	1.311-5.99E-04	1.303-5.10E-04	1.298-4.57E-04	1.295-4.20E-04	1.293-4.09E-04
2.5000	1.430-4.00E-03	1.399-1.55E-03	1.342-2.03E-03	1.203-2.02E-03	1.274-1.91E-03	1.260-1.86E-03	1.264-1.70E-03	1.263-1.76E-03
2.7000	1.400-7.00E-03	1.362-5.10E-03	1.290-1.32E-02	1.215-1.75E-02	1.204-1.81E-02	1.197-1.85E-02	1.192-1.88E-02	1.190-1.89E-02
3.0000	1.610-1.00E-02	1.567-5.76E-02	1.476 -.146	1.401 -.239	1.389 -.252	1.381 -.261	1.375 -.267	1.373 -.269
3.2000	1.490-3.00E-03	1.440-1.92E-02	1.404-4.93E-02	1.400-8.18E-02	1.475-8.57E-02	1.479-6.07E-02	1.478-9.07E-02	1.478-9.15E-02
3.3923	1.400-2.00E-03	1.449-5.34E-03	1.450-1.15E-02	1.429-1.81E-02	1.426-1.90E-02	1.424-1.96E-02	1.423-2.01E-02	1.423-2.02E-02
3.5000	1.400-1.60E-03	1.465-3.02E-03	1.439-5.64E-03	1.418-8.41E-03	1.406-8.82E-03	1.403-9.07E-03	1.401-9.25E-03	1.401-9.32E-03
3.7500	1.470-1.40E-03	1.452-1.70E-03	1.410-2.49E-03	1.382-3.23E-03	1.377-3.34E-03	1.373-3.41E-03	1.371-3.46E-03	1.370-3.46E-03
4.0000	1.400-1.40E-03	1.457-1.90E-03	1.413-3.96E-03	1.367-4.19E-03	1.361-4.30E-03	1.356-4.47E-03	1.353-4.54E-03	1.352-4.57E-03
4.5000	1.490-1.40E-03	1.461-3.50E-03	1.400-7.62E-03	1.352-1.19E-02	1.344-1.25E-02	1.339-1.29E-02	1.335-1.32E-02	1.334-1.33E-02
5.0000	1.470-2.50E-03	1.444-4.30E-03	1.395-7.63E-03	1.343-1.11E-02	1.336-1.17E-02	1.331-1.20E-02	1.328-1.22E-02	1.326-1.23E-02
5.5000	1.420-3.40E-03	1.390-5.05E-03	1.357-7.74E-03	1.314-1.06E-02	1.307-1.10E-02	1.303-1.13E-02	1.306-1.15E-02	1.299-1.15E-02
6.0000	1.410-1.10E-02	1.384-7.84E-02	1.335-6.07E-02	1.283-9.40E-02	1.276-9.99E-02	1.271 -.103	1.260 -.105	1.266 -.106
6.2000	1.600-2.20E-02	1.557-3.40E-02	1.477-5.62E-02	1.391-7.96E-02	1.381-8.31E-02	1.373-8.52E-02	1.367-8.60E-02	1.365-8.74E-02
6.5000	1.460-5.00E-03	1.430-1.12E-02	1.397-2.27E-02	1.356-3.40E-02	1.348-3.67E-02	1.344-3.70E-02	1.341-3.84E-02	1.340-3.89E-02
7.2000	1.420-7.43E-03	1.400-1.16E-02	1.364-2.03E-02	1.326-2.85E-02	1.320-3.32E-02	1.317-3.10E-02	1.314-3.16E-02	1.313-3.19E-02
7.9000	1.400-1.30E-02	1.381-1.60E-02	1.345-2.30E-02	1.307-3.12E-02	1.302-3.23E-02	1.298-3.30E-02	1.296-3.35E-02	1.295-3.37E-02
8.2000	1.420-2.00E-02	1.396-2.27E-02	1.351-2.70E-02	1.303-3.32E-02	1.296-3.40E-02	1.292-3.45E-02	1.289-3.48E-02	1.287-3.50E-02
8.5000	1.400-2.60E-02	1.443-2.79E-02	1.375-3.15E-02	1.304-3.53E-02	1.293-3.59E-02	1.286-3.62E-02	1.282-3.65E-02	1.280-3.65E-02
8.7000	1.600-3.00E-02	1.540-3.14E-02	1.430-3.41E-02	1.316-3.69E-02	1.296-3.73E-02	1.286-3.75E-02	1.278-3.77E-02	1.275-3.78E-02
9.0000	1.650-2.00E-02	1.580-3.02E-02	1.449-3.42E-02	1.311-3.80E-02	1.291-3.90E-02	1.270-3.94E-02	1.265-3.97E-02	1.260-3.98E-02
9.2000	1.610-2.60E-02	1.546-2.00E-02	1.426-3.40E-02	1.300-3.95E-02	1.281-4.03E-02	1.270-4.09E-02	1.262-4.12E-02	1.256-4.13E-02
9.5000	1.500-1.00E-02	1.519-2.20E-02	1.405-3.17E-02	1.286-4.10E-02	1.260-4.24E-02	1.257-4.32E-02	1.249-4.39E-02	1.246-4.41E-02
9.8000	1.560-1.60E-02	1.500-2.10E-02	1.389-3.29E-02	1.271-4.30E-02	1.256-4.55E-02	1.243-4.66E-02	1.235-4.73E-02	1.232-4.76E-02
10.0000	1.540-1.50E-02	1.482-2.15E-02	1.373-3.39E-02	1.259-4.62E-02	1.242-4.81E-02	1.231-4.93E-02	1.224-5.01E-02	1.221-5.05E-02
10.5910	1.500-1.40E-02	1.442-2.37E-02	1.336-4.17E-02	1.220-6.06E-02	1.203-6.34E-02	1.192-6.52E-02	1.185-6.64E-02	1.182-6.69E-02
11.0000	1.480-1.60E-02	1.421-2.90E-02	1.311-5.69E-02	1.195-6.63E-02	1.177-9.06E-02	1.167-9.33E-02	1.159-9.52E-02	1.156-9.64E-02
11.5000	1.480-1.40E-02	1.416-2.72E-02	1.297-8.02E-02	1.178 -.126	1.152 -.132	1.141 -.137	1.133 -.140	1.129 -.141
12.5000	1.420-1.60E-02	1.366-4.81E-02	1.266 -.142	1.161 -.220	1.145 -.241	1.135 -.249	1.129 -.254	1.126 -.257
13.0000	1.410-1.00E-02	1.362-7.01E-02	1.272 -.167	1.180 -.260	1.166 -.284	1.157 -.293	1.151 -.300	1.149 -.302
14.0000	1.410-2.30E-02	1.370-8.60E-02	1.306 -.203	1.235 -.326	1.225 -.344	1.218 -.355	1.214 -.363	1.212 -.367
14.8000	1.430-3.00E-02	1.399-9.65E-02	1.341 -.220	1.280 -.350	1.271 -.369	1.265 -.381	1.261 -.390	1.260 -.393
15.0000	1.450-3.50E-02	1.417 -.102	1.357 -.225	1.293 -.355	1.283 -.375	1.278 -.387	1.273 -.395	1.272 -.398
16.4000	1.560-9.00E-02	1.521 -.151	1.449 -.264	1.373 -.384	1.362 -.402	1.355 -.413	1.350 -.420	1.348 -.424
17.2000	1.740 -.120	1.676 -.176	1.557 -.200	1.431 -.390	1.412 -.406	1.401 -.416	1.393 -.423	1.389 -.426
18.0000	1.700 -.130	1.725 -.184	1.595 -.203	1.460 -.380	1.450 -.404	1.438 -.414	1.430 -.420	1.426 -.423
18.5000	1.770 -.135	1.711 -.187	1.601 -.203	1.485 -.395	1.467 -.408	1.457 -.409	1.449 -.416	1.446 -.418
20.0000	1.761 -.152	1.709 -.196	1.615 -.277	1.516 -.362	1.501 -.375	1.492 -.383	1.485 -.388	1.483 -.391
21.3000	1.760 -.165	1.711 -.204	1.621 -.276	1.525 -.352	1.511 -.363	1.502 -.370	1.496 -.375	1.494 -.377
22.5000	1.760 -.180	1.714 -.214	1.628 -.270	1.538 -.346	1.525 -.356	1.517 -.362	1.511 -.366	1.509 -.368
25.0000	1.780 -.205	1.718 -.232	1.641 -.283	1.560 -.337	1.548 -.345	1.541 -.350	1.535 -.353	1.533 -.355
27.9000	1.778 -.275	1.739 -.287	1.656 -.300	1.577 -.331	1.565 -.334	1.558 -.336	1.553 -.337	1.551 -.338
30.0000	1.779 -.300	1.730 -.305	1.657 -.315	1.579 -.324	1.567 -.326	1.560 -.327	1.555 -.327	1.553 -.328
35.0000	1.760 -.500	1.719 -.470	1.642 -.415	1.561 -.357	1.549 -.340	1.542 -.343	1.536 -.339	1.534 -.338
40.0000	1.760-1.000	1.700 -.800	1.626 -.601	1.547 -.463	1.535 -.431	1.528 -.411	1.523 -.397	1.521 -.391

A significant addition by Wells et al[54] to these other models is the inclusion of the effects of wind speed on the marine component of the aerosol distributions. They did this by modifying the parameters defining their size distribution as a function of wind, based on Woodcock's[51] data (while they cite Manson[57] as their source, the data can be traced to Woodcock through Junge[58,59]). They used a modified Γ size distribution,[60,61] with $\alpha = 2$,

$$\frac{dN}{dr} = n(r) = A\, r^{\alpha} \exp(-b r^{\gamma}) \qquad (7)$$

and fit A, which is proportional to the total number of particles, and γ, which is primarily the rate of decrease of the number density for the large particles as a function of wind speed. A simpler way of adding the effects of wind to our maritime model would be based on Lovett's work.[62,63] Based on his measurements of the concentration of sea-salt in the atmosphere as a function of wind speed, he derived the following empirical relationship

$$\ln \theta = 0.16\, v + 1.45 \qquad (8)$$

where θ is concentration of sea salt in $\mu g\ m^{-3}$ and v is the wind speed in m/sec. Making the simplifying assumption that this concentration is proportional to the total number of particles of oceanic origin, it can be shown that

$$N(v) = N(v_o) \cdot \exp[0.16\,(v - v_o)] \qquad (9)$$

where N(v) is the number of sea salt particulates for a wind speed v. Since Lovett's[62] measurements of relative mass distribution vs aerosol size show no significant dependence on wind speed, the assumption that particle number is proportional to the sea-salt mass is reasonable. It should be noted that the relevant indicator of wind speed is the mean prevailing wind speed, since the lifetime of these aerosols is on the order of a few days.

2.6 Tropospheric Model

The tropospheric aerosol model represents the aerosols within the troposphere above the boundary layer. These aerosols are assumed to have the same composition as the rural model (70 percent water-soluble and 30 percent dust-like). The size distribution is modified from the rural model by eliminating the large (or coarse) particle ($r_i = 0.5$) component of the size distribution because of the longer residence of aerosols above the boundary and the expected differential loss of the larger particles. This leaves the log-normal distribution with the small (or

accumulation) particle component. This is consistent with the changes in aerosol size distribution with altitude suggested by Whitby and Cantrell.[17] The dependence of particle size on relative humidity is the same as for the small particle component of the rural model, and is shown in Figures 9-11.

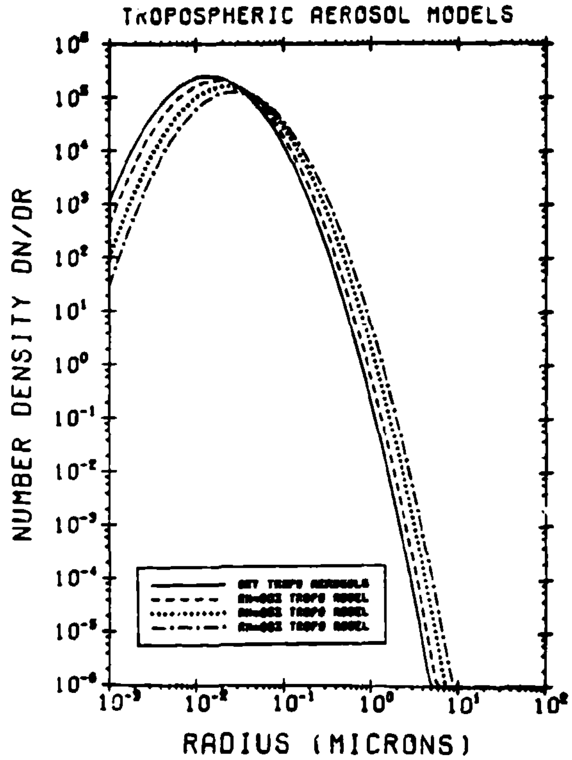

Figure 9. Aerosol Number Distribution (cm^{-3} μm^{-1}) for the Tropospheric Model at Different Relative Humidities With Total Particle Concentrations Fixed at 10,000 cm^{-3}

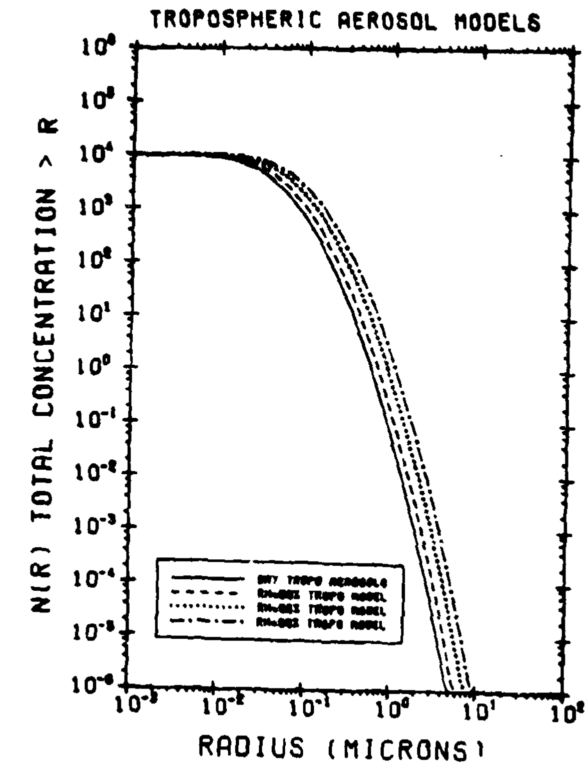

Figure 10. Cumulative Number Density (cm^{-3}) for the Tropospheric Aerosol Model at Different Relative Humidities With Total Particle Concentrations Fixed at 10,000 cm^{-3}

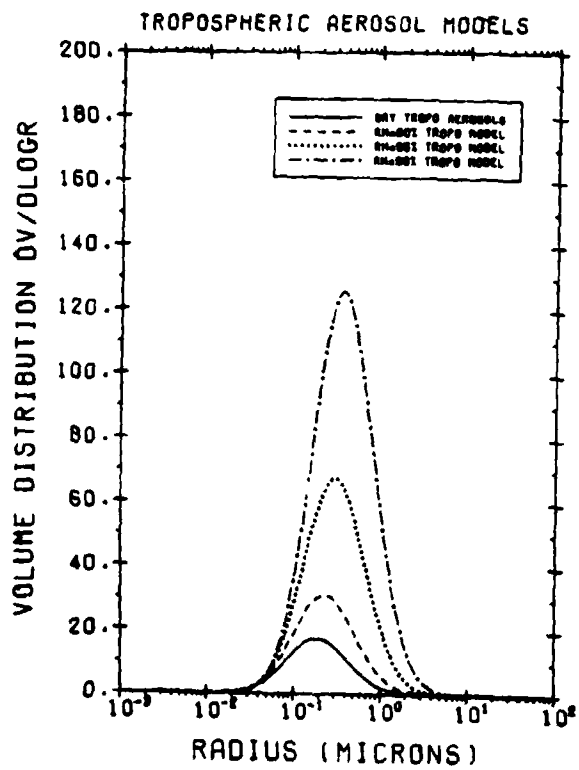

Figure 11. Volume Distribution ($\mu m^3/cm^3$) for the Tropospheric Aerosol Model at Different Relative Humidities With the Total Particle Concentrations Fixed at 10,000 cm^{-3}

2.7 Fog Models

When the air becomes nearly saturated with water vapor (relative humidity close to 100 percent), fog can form (assuming sufficient condensation nuclei are present). The air can become saturated in two ways, either by mixing of air masses with different temperatures and/or humidities (advection fogs), or by the air cooling until the air temperature approaches the dew point temperature (radiation fogs).[64]

To represent the range of the different types of fog, we use the fog models presented by Silverman and Sprague,[65] following the work of Dyachenko.[66] These were chosen to represent the range of measured size distributions, and correspond to what Silverman and Sprague identified as typical of radiation fogs and advection fogs, although they are also characteristic of developing and mature fogs, respectively. They use a modified gamma size distribution [Eq. (7)] to describe the size distribution.

The values of the parameters, A, α, b, γ are given in Table 7 along with the mode radius and total particle number.

Table 7. Size Distribution Parameters of the Fog Models

Type of Fog	Model	A	α	b	γ	r_{mode} (μ)	N_o (cm^{-3})
Advection Fog	1	0.06592	3	0.3	1	10.0	20
	2	0.027	3	0.375	1	8.0	20
Radiation Fog	3	2.37305	6	1.5	1	4.0	100
	4	607.5	6	3.0	1	2.0	200

Models 1 and 3 represent heavy, and Models 2 and 4 moderate fog conditions for the different types. Generally, measured fog droplet size distributions[66-70] fall within the variations represented by these models. For example, extensive measurements of valley fog by Pilie et al[67,68] have shown that developing fog is characterized by droplet concentrations of 100 to 200 particles per cm^3 in the 1 to 10 μm radius range with mean radius of 2 to 4 μm. As the fog thickens, the droplet concentration decreases to less than 2 particles per cm^3 and mean radius increases from 6 to 12 μm. Droplets less than 3 μm radius were seldom observed in fully developed fog.

It was assumed the refractive index for the fog was that of pure water. While most of the fog droplets have condensation nuclei, the effect on the refractive index was considered to be negligible compared with the other uncertainties in these models. The size distribution for the fog models is shown in Figures 12-14.

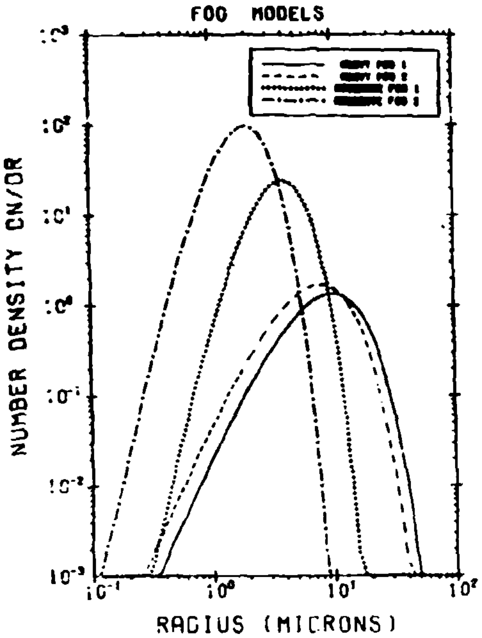

Figure 12. Number Distribution (cm^{-3} μm^{-1}) for the Different Fog Models

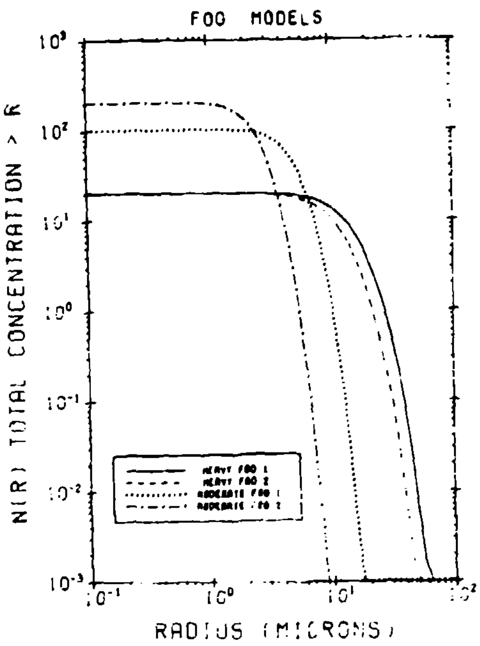

Figure 13. Cumulative Number (cm^{-3}) Distribution for the Different Fog Models

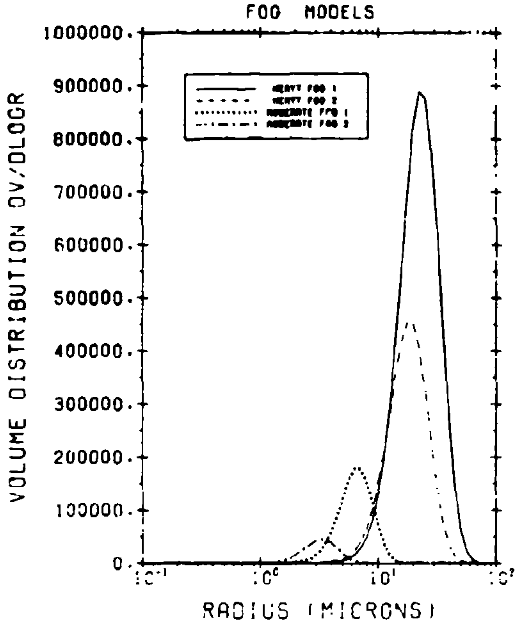

Figure 14. Volume Distribution ($\mu m^3/cm^3$) for the Different Fog Models

3. AEROSOL OPTICAL PROPERTIES

3.1 Mie Scattering Calculations

Once the size distribution and refractive index of the aerosol models are specified, the optical properties, such as the scattering or absorption coefficients can be calculated from Mie theory.[71-74] There are a number of versions of Mie scattering computer codes available for such computations (for example, Dave,[75] and Hansen and Travis[76]). For the present work, a modified version of a program developed by RRA for AFGL[77] was used. The most important modification on it was to use downward recursion to calculate the logarithmic derivative of the Ricatti-Bessel function used in calculating the Mie coefficients to avoid the numerical instabilities that develop with these calculations for large absorbing particles when upward recursion is used.[75,78]

For the Mie scattering calculations the aerosol particles are assumed to be spherical, which is not in general true. While liquid aerosols will be approximately spherical, the dry particles usually are irregularly shaped. However it can be argued that many of the measurements of aerosol size distributions are measuring scattered light[79-82] and the size "assigned" to a given particle, is the size of a sphere that has similar scattering properties to the measured particle. Furthermore, the irregular shaped particles are closest to "equivalent" spheres in their

scattering properties in the forward direction generally used for size measurements.[83, 84] So the resulting size distribution is the size distribution of spheres that have similar optical properties to the actual aerosol particles. Also studies by Chylek[83] and Holland and Gagne[84] indicate that for particles of equal overall dimensions but different shapes, the spherical particle extinction has the highest values.

3.2 Aerosol Model Attenuation

The attenuation coefficients for the rural aerosol model at 50 percent and 95 percent relative humidity are shown in Figures 15 and 16 as a function of wavelength. To show the effect of variations of relative humidity on the aerosol extinction, the rural model extinction has been calculated over a range of humidities for a constant total number density. The resulting extinction vs wavelength is shown in Figure 17 for several relative humidities between 0 and 99 percent where the number density is held fixed at 15,000 particles/cm^3, which correspond to a meteorological range of about 25 km for the dry aerosols and about 5 km at 99 percent relative humidity.

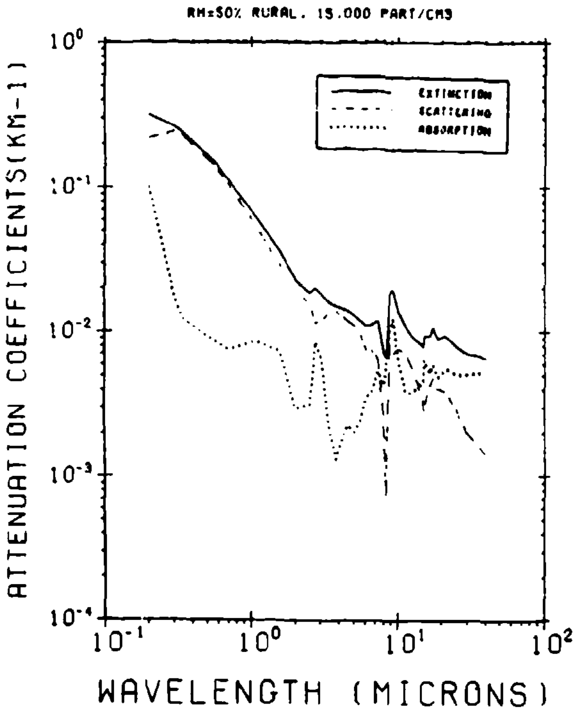

Figure 15. Attenuation Coefficients vs Wavelength for the Rural Aerosols at 50 Percent Relative Humidity

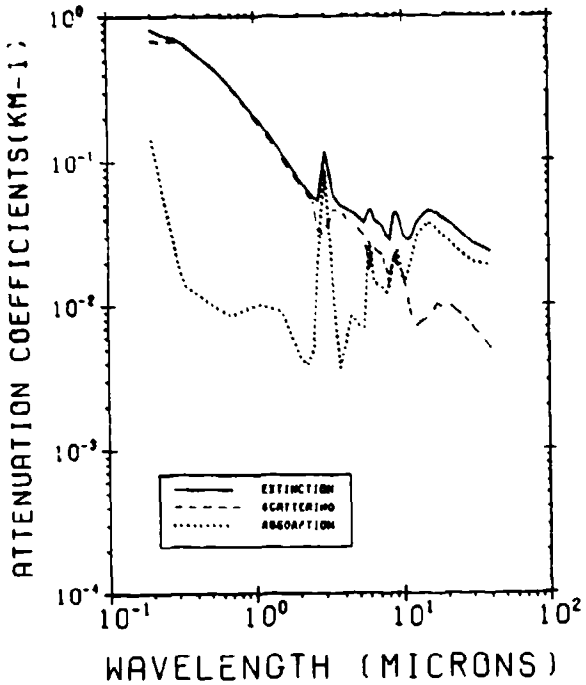

Figure 16. Attenuation Coefficients vs Wavelength for the Rural Aerosol Model at 95 Percent Relative Humidity

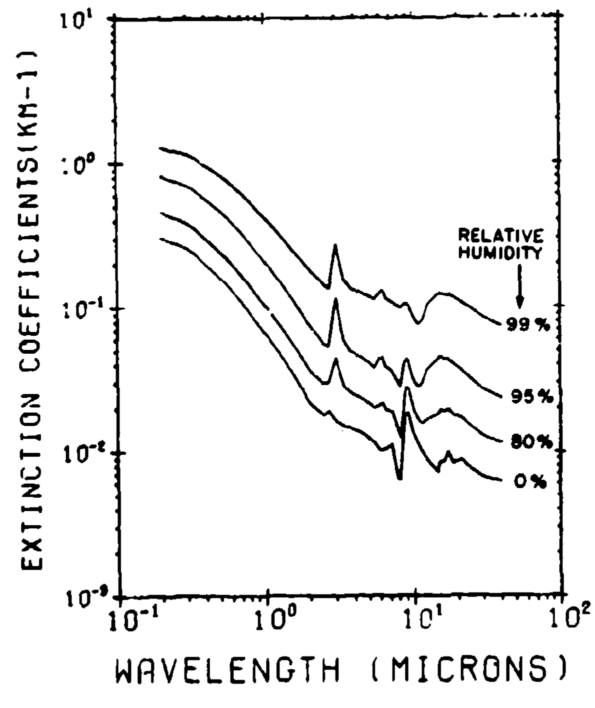

Figure 17. Extinction Coefficients vs Wavelength for the Rural Aerosol Model for Different Relative Humidities and Constant Number Density of Particles

The development of the 3-μm water absorption feature with increasing relative humidity is apparent in these figures. Also apparent from these figures is the masking of the strong dispersion from the 9 μm sulfate in the dry aerosol by the water condensed on the aerosol.

The attenuation coefficients for the urban aerosol model are shown in Figures 18 through 20 as a function of wavelength, for several different humidities. The corresponding results for the maritime and tropospheric aerosol models are shown in Figures 21 through 23 and Figures 24 through 26 respectively.

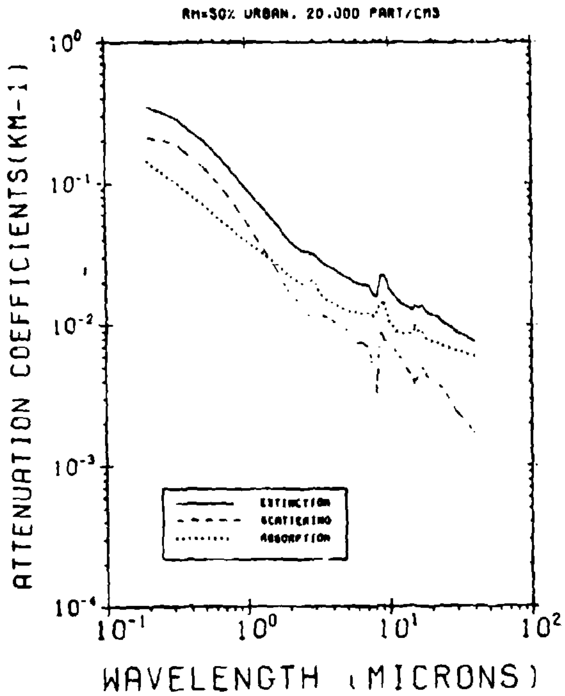

Figure 18. Attenuation Coefficients vs Wavelength for the Urban Aerosols at 50 Percent Relative Humidity

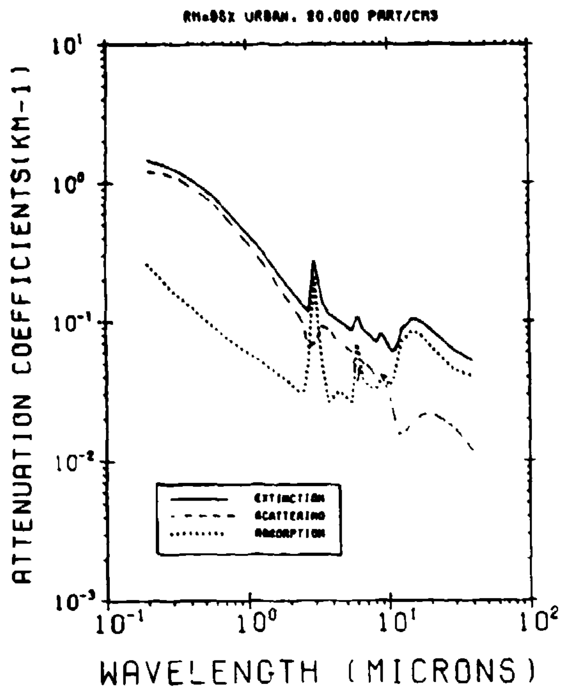

Figure 19. Attenuation Coefficients vs Wavelength for the Urban Aerosols at 95 Percent Relative Humidity

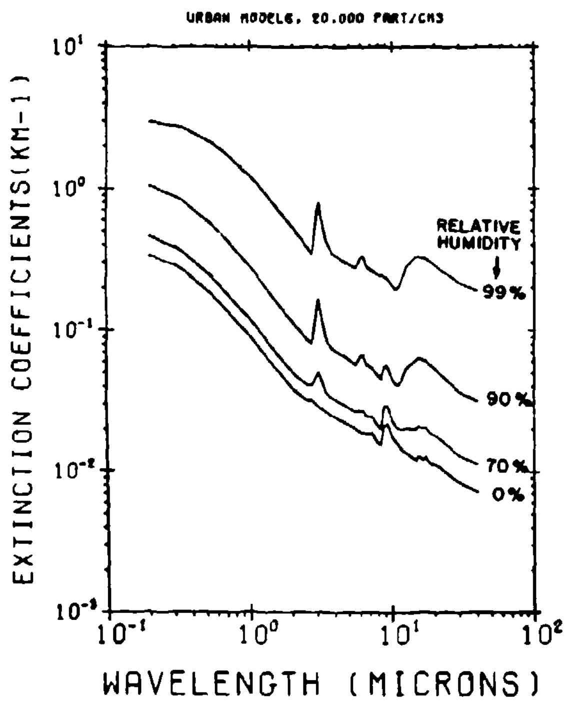

Figure 20. Extinction Coefficients vs Wavelength for the Urban Aerosol Model for Different Relative Humidities and Constant Number Density of Particles

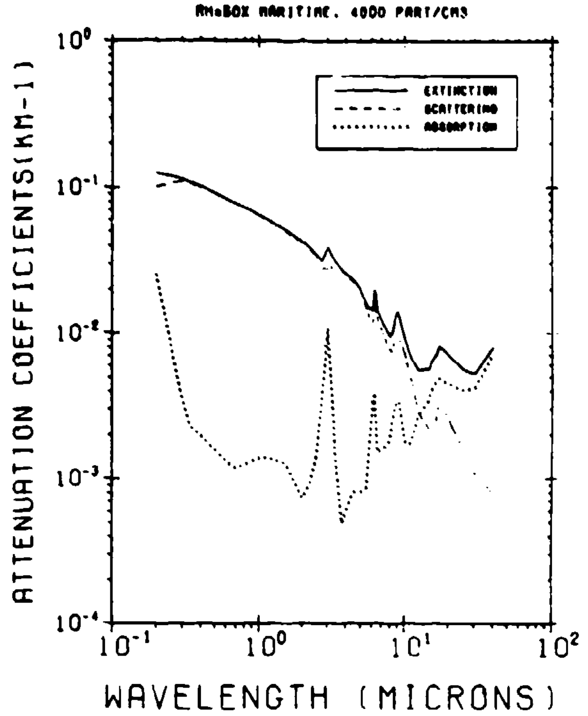

Figure 21. Attenuation Coefficients vs Wavelength for the Maritime Aerosol Model at 50 Percent Relative Humidity

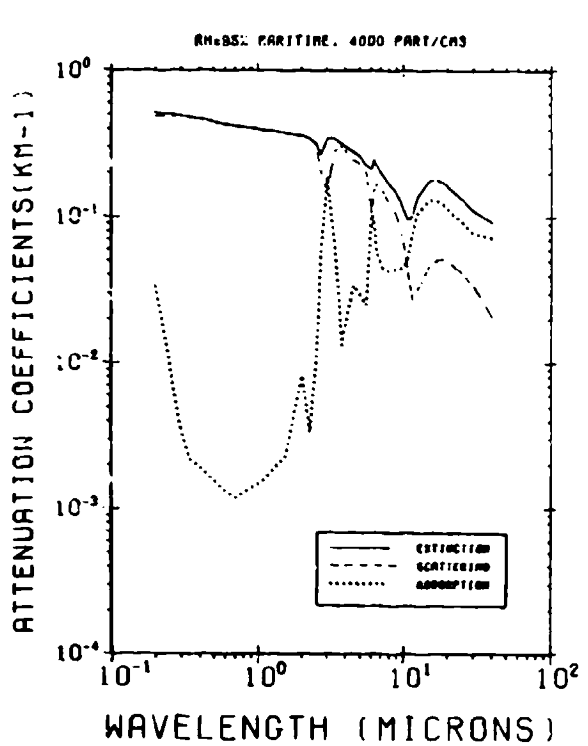

Figure 22. Attenuation Coefficients vs Wavelength for the Maritime Aerosol Model at 95 Percent Relative Humidity

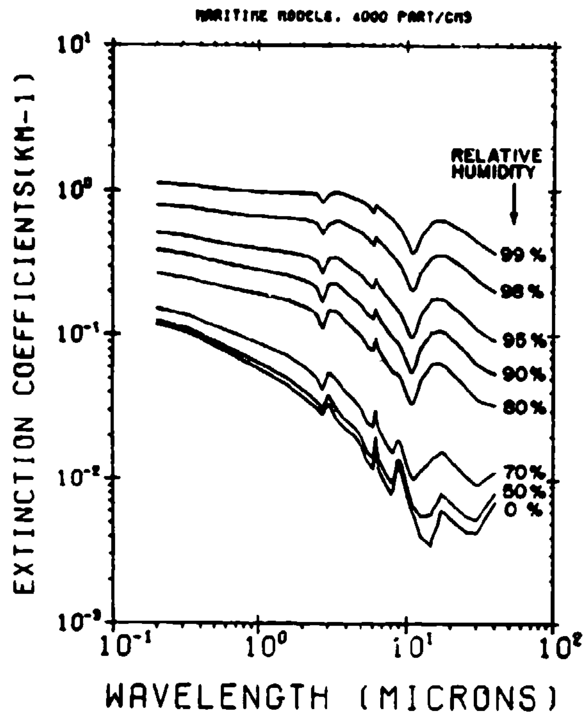

Figure 23. Extinction Coefficients vs Wavelength for the Maritime Aerosol Model for Different Relative Humidities and Constant Number Density of Particles

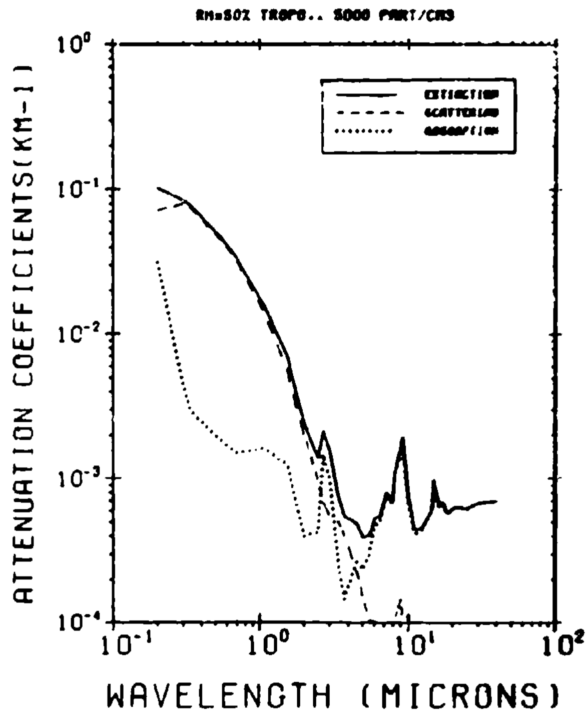

Figure 24. Attenuation Coefficients vs Wavelength for the Tropospheric Aerosol Model at 50 Percent Relative Humidity

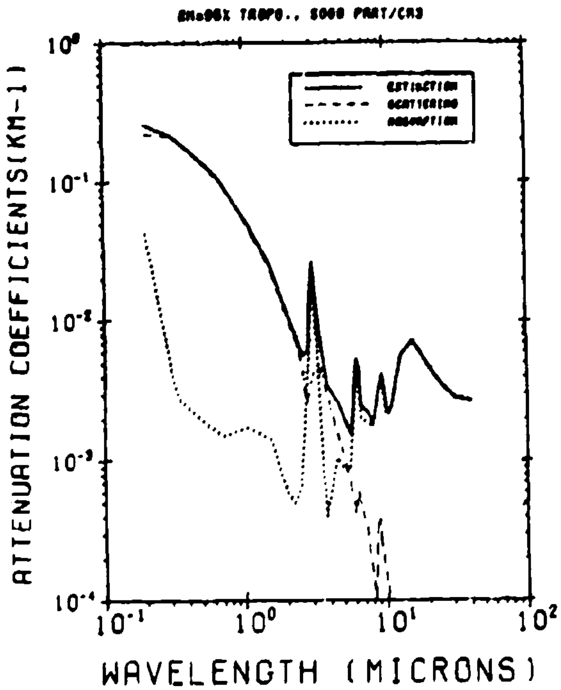

Figure 25. Attenuation Coefficients vs Wavelength for the Tropospheric Aerosol Model at 95 Percent Relative Humidity

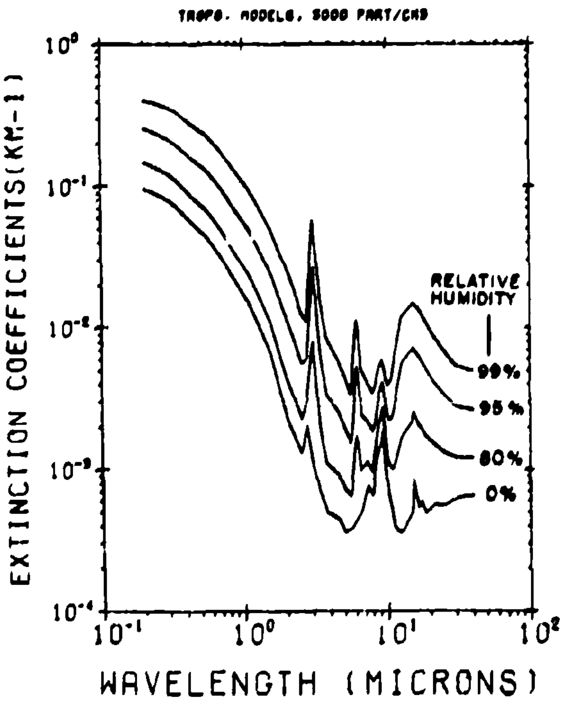

Figure 26. Extinction Coefficients vs Wavelength for the Tropospheric Aerosol Model for Different Relative Humidities and Constant Number Density of Particles

One feature common to all these models is the reduction in the slope of the extinction coefficient vs wavelength with increasing relative humidity. This is due to the growth of the aerosols, which is greatest for the larger particles, and the corresponding increased contribution of scattering to the total extinction, especially in the infrared.

The total number of particles for the components of the different aerosol models are given in Tables 8 through 11 normalized to different meteorological ranges, V, for various relative humidities. Using Koschmieder's law or the visual range formula[85, 86] at a wavelength of 0.55 microns,

$$V = \frac{1}{\sigma} \ln \frac{1}{\epsilon} = \frac{3.912}{\sigma} \tag{10}$$

where ϵ, the threshold contrast is 2 percent and $\sigma = \sigma_{molecular} + \sigma_{aerosol}$, is the total extinction.* The N_1 and N_2 in the tables are the appropriately normalized values of the N_i in Table 1, where $i = 1$ is the small particle component and $i = 2$ the large particle component. It is important to note that caution should be exercised in comparing total numbers of aerosol particles between various models and/or measured number densities. The results depend on the details of the small particle distributions; for models, the total numbers are most sensitive to the assumed distribution of the smallest particles, and for measurements, the total numbers are most sensitive to the small particle cut-off characteristics of the measuring instrument. This can be seen from any of the plots of the aerosol cumulative number density (Figures 4, 7, or 10) where changing the small particle cut-off from 0.1 to 1.0 μm (a representative range for particle counters) will change the total number of aerosol particles counted, by a factor between 100 and 1000. The smallest aerosols (less than 0.1 μm) are usually the least important particles in terms of the optical or IR properties.

*Strictly speaking the extinction should be weighted by the photopic response of the eye, and the effects of absorption neglected in deriving Eq. (10).

Table 8. Total Number Density for the Rural Aerosol Model as a Function of Relative Humidity and Meteorological Range

RELATIVE HUMIDITY =		0.	50.	70.	80.	90.	95.	98.	99.
VISIBILITY = 2. KM.	N1 =	199538.58	192537.16	178656.18	129883.79	85526.28	68260.42	48674.99	37244.91
	N2 =	24.94	24.07	22.33	16.24	10.69	8.53	6.89	4.66
VISIBILITY = 5. KM.	N1 =	79076.33	76304.75	70803.53	51474.48	33895.87	27052.41	19299.47	14760.60
	N2 =	9.89	9.54	8.85	6.44	4.24	3.38	2.41	1.85
VISIBILITY = 10. KM.	N1 =	38924.91	37563.62	34852.67	25338.05	16684.67	13316.41	9495.64	7265.83
	N2 =	4.87	4.70	4.36	3.17	2.09	1.66	1.19	.91
VISIBILITY = 23. KM.	N1 =	16230.63	15661.76	14532.62	10565.23	6957.06	5552.58	3959.42	3029.65
	N2 =	2.03	1.96	1.82	1.32	.87	.69	.49	.38
VISIBILITY = 50. KM.	N1 =	6803.78	6565.31	6091.98	4428.90	2916.35	2327.61	1659.76	127[illegible].01
	N2 =	.85	.82	.76	.55	.36	.29	.21	.16

Table 9. Total Number Density for the Urban Aerosol Model as a Function of Relative Humidity and Meteorological Range

RELATIVE HUMIDITY =		0.	50.	70.	80.	90.	95.	98.	99.
VISIBILITY = 2. KM.	N1 =	220039.51	210325.47	163580.19	107935.91	69877.38	45967.45	26535.53	18383.38
	N2 =	27.51	26.29	20.45	13.49	8.74	5.75	3.32	2.30
VISIBILITY = 5. KM.	N1 =	87294.26	83354.47	64828.76	42776.28	27693.23	18217.44	10516.34	7285.55
	N2 =	10.90	10.42	8.10	5.35	3.46	2.28	1.31	.91
VISIBILITY = 10. KM.	N1 =	42925.84	41030.80	31911.62	21056.48	13631.85	8967.44	5176.62	3586.27
	N2 =	5.37	5.13	3.99	2.63	1.70	1.12	.65	.45
VISIBILITY = 23. KM.	N1 =	17898.91	17108.73	13306.28	8779.95	5684.11	3739.10	2158.51	1495.38
	N2 =	2.24	2.14	1.66	1.10	.71	.47	.27	.19
VISIBILITY = 50. KM.	N1 =	7583.11	7171.87	5577.91	3680.50	2382.74	1567.44	904.83	626.85
	N2 =	.94	.90	.70	.46	.30	.20	.11	.08

Table 10. Total Number Density for the Maritime Aerosol Model as a Function of Relative Humidity and Meteorological Range

RELATIVE HUMIDITY =		0.	50.	70.	80.	90.	95.	98.	99.
VISIBILITY =	2. KM.								
	N1 =	96516.79	88640.83	70038.09	35078.01	24467.13	17683.12	11083.66	7438.74
	N2 =	974.92	895.36	707.46	354.32	247.14	177.81	111.12	75.14
VISIBILITY =	5. KM.								
	N1 =	38250.75	35129.41	27756.92	13901.83	9696.61	6976.32	4359.67	2948.06
	N2 =	386.37	354.84	280.37	140.42	97.95	70.47	44.04	29.78
VISIBILITY =	10. KM.								
	N1 =	18828.73	17292.27	13663.20	6843.10	4773.11	3434.06	2146.02	1451.17
	N2 =	190.19	174.67	138.01	69.12	48.21	34.69	21.68	14.66
VISIBILITY =	23. KM.								
	N1 =	7851.07	7210.41	5697.10	2853.39	1990.26	1431.91	894.83	605.10
	N2 =	79.30	72.83	57.55	28.82	20.10	14.46	9.04	6.11
VISIBILITY =	50. KM.								
	N1 =	3291.12	3022.56	2388.22	1196.12	834.30	600.25	375.11	253.65
	N2 =	33.24	30.53	24.12	12.08	8.43	6.06	3.79	2.56

Table 11. Total Number Density for the Tropospheric Aerosol Model as a Function of Relative Humidity and Meteorological Range

RELATIVE HUMIDITY =		0.	50.	70.	80.	90.	95.	98.	99.
VISIBILITY =	2. KM.								
	N1 =	219977.62	212240.41	197183.94	143715.10	93745.27	74441.95	54687.15	42396.01
	N2 =	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VISIBILITY =	5. KM.								
	N1 =	87179.73	84113.38	78114.62	56955.99	37152.36	29502.22	21673.16	16802.04
	N2 =	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VISIBILITY =	10. KM.								
	N1 =	42913.77	41404.38	38451.52	28036.29	18288.05	14522.32	10668.50	8270.72
	N2 =	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VISIBILITY =	23. KM.								
	N1 =	17893.88	17264.50	16033.24	11690.37	7625.62	6055.41	4448.40	3448.66
	N2 =	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VISIBILITY =	50. KM.								
	N1 =	7501.08	7237.17	6721.03	4900.53	3196.61	2538.39	1864.77	1445.66
	N2 =	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

3.3 Fog Model Attenuation

The attenuation coefficients for the fog models are shown in Figures 27 through 31, using the number densities given in Table 7. The meteorological ranges for these droplet concentrations vary from 130 m for Fog Model 1 (Advection Fog) to 450 m for Fog Model 4 (Radiation Fog). However, the models are representative of heavy fogs with visibilities of less than 50 m, to light fogs with visibilities over 1 km, and can be scaled to visibilities over this range.

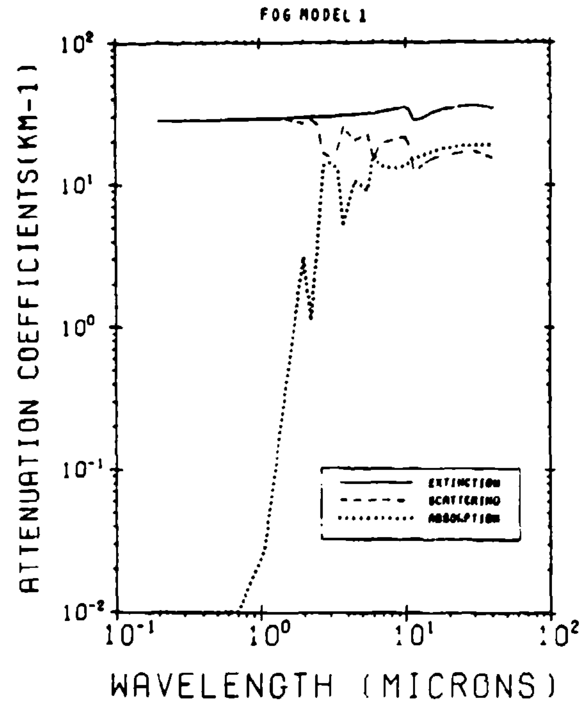

Figure 27. Attenuation Coefficients vs Wavelength; Heavy Advection Fog Model 1

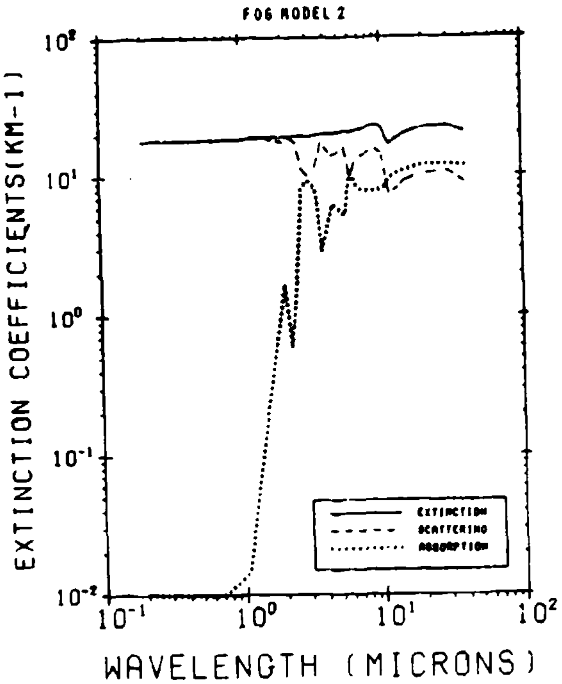

Figure 28. Attenuation Coefficients vs Wavelength; Light to Moderate Advection Fog Model 2

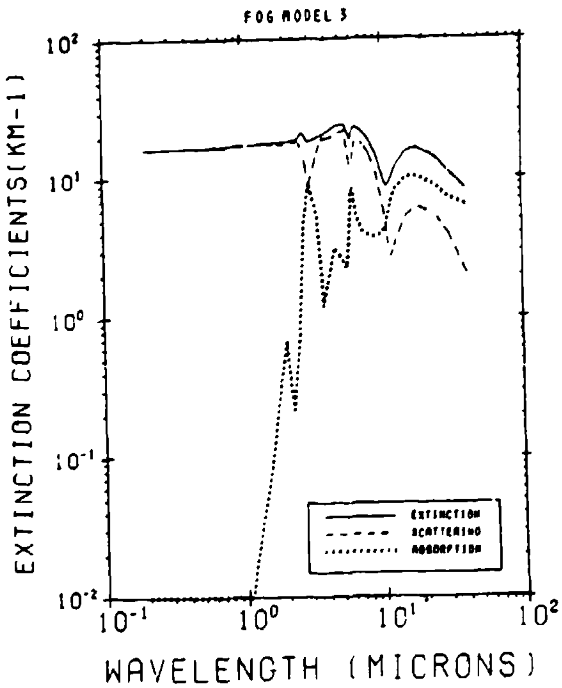

Figure 29. Attenuation Coefficients vs Wavelength; Heavy Radiation Fog, Model 3

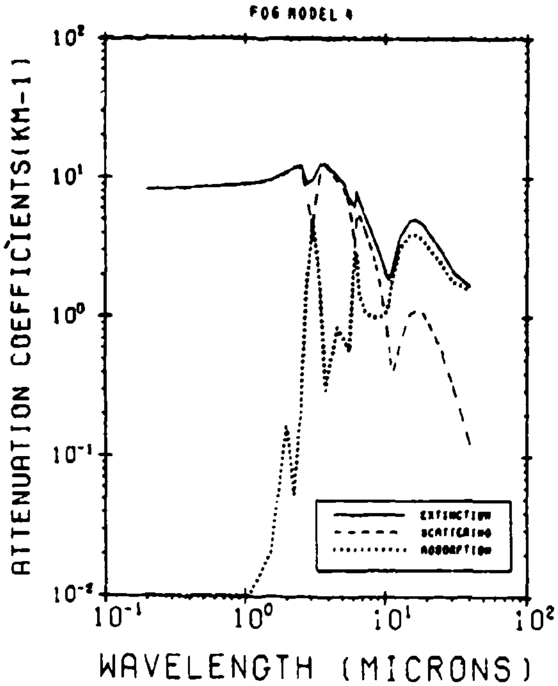

Figure 30. Attenuation Coefficients vs Wavelength; Light to Moderate Radiation Fog, Model 4

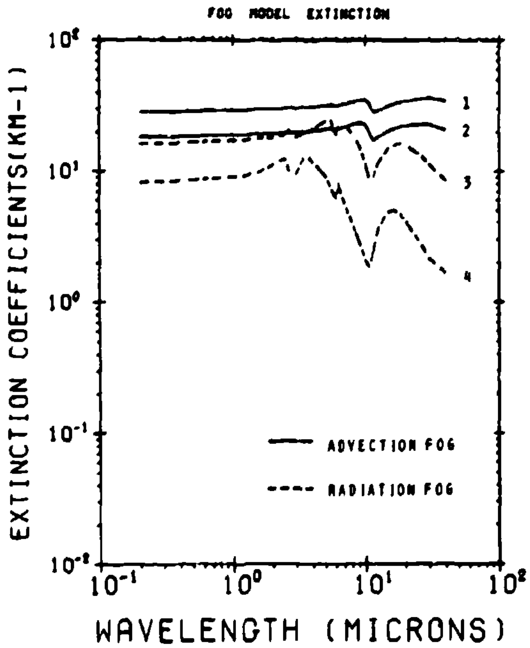

Figure 31. Extinction Coefficients vs Wavelength for the Different Fog Models. Models 1 and 2 are for heavy and light Advection Fog. Models 3 and 4 are for heavy and light Radiation Fog

3.4 Tables of Aerosol Attenuation

The attenuation coefficients for the different aerosol models are given in Tables 12 through 47. These attenuation coefficients in the tables are normalized to different number densities characteristic of the different types of aerosol, with the total number of particles being the same for each of the different humidities, for which the results are tabulated. This permits examination of how the optical properties of a given type of aerosol change with changes in the relative humidity, assuming no other processes, such as nucleation, coagulation, or sedimentation, affect the size distribution.

These tables also include the albedo for single scatter, a, which is the ratio of the scattering to total extinction cross-sections

$$a = \frac{\sigma_{scat}}{\sigma_{ext}} = \frac{\sigma_{scat}}{\sigma_{scat} + \sigma_{abs}} . \tag{11}$$

Because it provides a convenient one parameter representation for the angular dependence of scattering by the aerosols, the asymmetry parameter, g, also has been given. The asymmetry parameter is defined as the cosine weighted average of the phase function, $P(\theta)$

$$g = \frac{\int_{-1}^{+1} \cos\theta \; P(\theta)\, d(\cos\theta)}{\int_{-1}^{+1} P(\theta)\, d(\cos\theta)} \tag{12}$$

where $P(\theta)$ is the differential probability of scattering at an angle θ.

The asymmetry parameter is particularly useful when multiple scattering effects are significant, and the details of the scattering function are smoothed out; then g characterizes the angular distribution of the radiation field in approximate radiative transfer methods as the Eddington approximation,[87] the Delta Eddington approximation,[88] and various forms of the Two-stream approximation.[89,90] Using the asymmetry parameter with the Henyey-Greenstein[91] phase function

$$P(\theta) = \frac{(1-g^2)}{[1+g^2-2g\cos\theta]^{3/2}} \tag{13}$$

reasonably accurate intensities can be determined with the more exact radiative transfer methods.[92] However, for single scattering calculations this or any other one parameter approximation to the phase function should only be used with extreme caution.

Table 12. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 0% Rural Model

NORMALIZED TO A NUMBER DENSITY OF 1.5000E+04 PARTICLES/CM3					
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	3.058E-01	2.076E-01	9.819E-02	.6789	.7981
.300	2.551E-01	2.377E-01	1.744E-02	.9316	.6705
.337	2.345E-01	2.221E-01	1.243E-02	.9470	.6712
.550	1.461E-01	1.375E-01	8.665E-03	.9407	.6479
.694	1.099E-01	1.024E-01	7.528E-03	.9315	.6342
1.060	6.129E-02	5.279E-02	8.502E-03	.8613	.6176
1.536	3.517E-02	2.786E-02	7.316E-03	.7920	.6334
2.000	2.149E-02	1.862E-02	2.879E-03	.8661	.7063
2.250	1.944E-02	1.641E-02	3.029E-03	.8442	.7271
2.500	1.787E-02	1.480E-02	3.073E-03	.8281	.7463
2.700	1.936E-02	1.110E-02	8.262E-03	.5733	.7788
3.000	1.636E-02	1.229E-02	4.068E-03	.7513	.7707
3.392	1.525E-02	1.332E-02	1.925E-03	.8738	.7424
3.750	1.455E-02	1.328E-02	1.270E-03	.9127	.7312
4.500	1.342E-02	1.129E-02	2.135E-03	.8410	.7442
5.000	1.235E-02	1.043E-02	1.914E-03	.8449	.7516
5.500	1.149E-02	9.114E-03	2.375E-03	.7933	.7662
6.000	1.027E-02	7.326E-03	2.943E-03	.7134	.7940
6.200	1.036E-02	7.199E-03	3.163E-03	.6947	.7886
6.500	1.051E-02	7.053E-03	3.461E-03	.6708	.7797
7.200	1.139E-02	6.215E-03	5.170E-03	.5459	.7664
7.900	6.548E-03	2.419E-03	4.129E-03	.3694	.8525
8.200	6.432E-03	6.445E-04	5.787E-03	.1002	.8730
8.700	1.780E-02	7.898E-03	9.906E-03	.4436	.5846
9.000	1.850E-02	7.858E-03	1.064E-02	.4248	.5570
9.200	1.875E-02	6.885E-03	1.187E-02	.3672	.5992
10.000	1.337E-02	7.478E-03	5.893E-03	.5593	.6159
10.591	1.180E-02	7.165E-03	4.639E-03	.6070	.6271
11.000	1.090E-02	7.164E-03	3.735E-03	.6573	.6257
11.500	1.006E-02	6.637E-03	3.418E-03	.6601	.6374
12.500	8.816E-03	5.634E-03	3.183E-03	.6390	.6546
14.000	7.233E-03	3.397E-03	3.836E-03	.4697	.6861
15.000	8.556E-03	2.795E-03	5.761E-03	.3266	.6859
16.400	8.766E-03	4.212E-03	4.554E-03	.4805	.6120
17.200	1.018E-02	4.773E-03	5.405E-03	.4689	.5570
18.500	8.362E-03	4.041E-03	4.322E-03	.4832	.5813
21.300	8.839E-03	3.727E-03	5.112E-03	.4217	.5341
25.000	7.569E-03	2.834E-03	4.735E-03	.3744	.5284
30.000	6.708E-03	1.893E-03	4.815E-03	.2821	.5137
40.000	6.289E-03	1.354E-03	4.935E-03	.2154	.4348

Table 13. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 50% Rural Model

NORMALIZED TO A NUMBER DENSITY OF 1.5900E+04 PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	3.172E-01	2.177E-01	9.954E-02	.6862	.7598
.300	2.641E-01	2.467E-01	1.741E-02	.9341	.6836
.337	2.428E-01	2.303E-01	1.246E-02	.9487	.6762
.550	1.514E-01	1.428E-01	8.681E-03	.9427	.6534
.694	1.139E-01	1.064E-01	7.565E-03	.9336	.6392
1.060	6.361E-02	5.504E-02	8.571E-03	.8653	.6220
1.536	3.653E-02	2.914E-02	7.386E-03	.7979	.6365
2.000	2.241E-02	1.950E-02	2.912E-03	.8701	.7070
2.250	2.024E-02	1.718E-02	3.051E-03	.8492	.7277
2.500	1.856E-02	1.545E-02	3.110E-03	.8324	.7478
2.700	2.000E-02	1.151E-02	8.486E-03	.5757	.7821
3.000	1.824E-02	1.178E-02	6.459E-03	.6459	.7759
3.392	1.605E-02	1.390E-02	2.148E-03	.8662	.7407
3.750	1.520E-02	1.389E-02	1.311E-03	.9137	.7311
4.500	1.400E-02	1.175E-02	2.247E-03	.8395	.7460
5.000	1.287E-02	1.086E-02	2.009E-03	.8440	.7535
5.500	1.196E-02	9.504E-03	2.455E-03	.7947	.7685
6.000	1.090E-02	7.424E-03	3.480E-03	.6808	.7982
6.200	1.104E-02	7.445E-03	3.595E-03	.6744	.7899
6.500	1.103E-02	7.377E-03	3.656E-03	.6686	.7810
7.200	1.182E-02	6.503E-03	5.322E-03	.5499	.7680
7.900	6.947E-03	2.676E-03	4.272E-03	.3852	.8519
8.200	6.676E-03	7.442E-04	5.932E-03	.1115	.8719
8.700	1.841E-02	8.192E-03	1.022E-02	.4450	.5924
9.000	1.918E-02	8.156E-03	1.102E-02	.4253	.5652
9.200	1.938E-02	7.124E-03	1.226E-02	.3676	.6074
10.000	1.377E-02	7.693E-03	6.076E-03	.5587	.6249
10.591	1.215E-02	7.315E-03	4.833E-03	.6022	.6374
11.000	1.123E-02	7.244E-03	3.988E-03	.6449	.6376
11.500	1.040E-02	6.633E-03	3.765E-03	.6380	.6508
12.500	9.256E-03	5.508E-03	3.749E-03	.5950	.6684
14.800	7.878E-03	3.356E-03	4.523E-03	.4259	.6919
15.000	9.225E-03	2.830E-03	6.394E-03	.3068	.6892
16.400	9.362E-03	4.205E-03	5.157E-03	.4492	.6200
17.200	1.074E-02	4.817E-03	5.926E-03	.4484	.5657
18.500	8.915E-03	4.071E-03	4.845E-03	.4566	.5885
21.300	9.319E-03	3.815E-03	5.504E-03	.4094	.5404
25.000	7.989E-03	2.922E-03	5.067E-03	.3658	.5331
30.000	7.062E-03	1.973E-03	5.089E-03	.2794	.5178
40.000	6.603E-03	1.411E-03	5.192E-03	.2137	.4399

Table 14. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 70% Rural Model

NORMALIZED TO A NUMBER DENSITY OF 1.5000E+04 PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	3.420E-01	2.392E-01	1.028E-01	.6995	.7632
.300	2.842E-01	2.666E-01	1.765E-02	.9379	.6928
.337	2.611E-01	2.486E-01	1.252E-02	.9521	.6865
.550	1.632E-01	1.544E-01	8.777E-03	.9462	.6638
.694	1.229E-01	1.153E-01	7.641E-03	.9378	.6498
1.060	6.882E-02	6.011E-02	8.711E-03	.8734	.6314
1.536	3.970E-02	3.217E-02	7.527E-03	.8104	.6440
2.000	2.466E-02	2.167E-02	2.986E-03	.8789	.7798
2.250	2.221E-02	1.911E-02	3.102E-03	.8603	.7303
2.500	2.029E-02	1.709E-02	3.200E-03	.8423	.7522
2.700	2.158E-02	1.256E-02	9.017E-03	.5821	.79[illegible]3
3.000	2.256E-02	1.143E-02	1.112E-02	.5068	.7874
3.392	1.807E-02	1.538E-02	2.695E-03	.8509	.7380
3.750	1.685E-02	1.544E-02	1.413E-03	.9161	.7319
4.500	1.547E-02	1.294E-02	2.522E-03	.8369	.7538
5.000	1.424E-02	1.200E-02	2.242E-03	.8426	.7584
5.500	1.318E-02	1.053E-02	2.652E-03	.7988	.7738
6.000	1.247E-02	7.745E-03	4.725E-03	.6211	.8071
6.200	1.273E-02	8.112E-03	4.616E-03	.6373	.7929
6.500	1.237E-02	8.234E-03	4.135E-03	.6657	.7843
7.200	1.296E-02	7.266E-03	5.694E-03	.5606	.7747
7.900	7.997E-03	3.372E-03	4.624E-03	.4217	.6507
8.200	7.390E-03	1.100E-03	6.290E-03	.1488	.8750
8.700	1.985E-02	8.946E-03	1.091E-02	.4506	.6112
9.000	2.079E-02	8.919E-03	1.187E-02	.4290	.5651
9.200	2.096E-02	7.737E-03	1.312E-02	.37[illegible]9	.6272
10.000	1.474E-02	8.237E-03	6.506E-03	.5587	.6466
10.591	1.299E-02	7.689E-03	5.301E-03	.5919	.6616
11.000	1.204E-02	7.445E-03	4.600E-03	.6181	.6653
11.500	1.123E-02	6.639E-03	4.592E-03	.5911	.6798
12.500	1.033E-02	5.275E-03	5.058E-03	.5105	.6965
14.000	9.454E-03	3.345E-03	6.109E-03	.3538	.7026
15.000	1.085E-02	2.965E-03	7.881E-03	.2734	.6960
16.400	1.083E-02	4.256E-03	6.578E-03	.3928	.6360
17.200	1.214E-02	4.963E-03	7.180E-03	.4087	.5848
18.500	1.029E-02	4.200E-03	6.090E-03	.4082	.6033
21.300	1.051E-02	4.055E-03	6.460E-03	.3856	.5547
25.000	9.042E-03	3.163E-03	5.879E-03	.3498	.5445
30.000	7.948E-03	2.192E-03	5.756E-03	.2758	.5274
40.000	7.379E-03	1.562E-03	5.817E-03	.2117	.4518

Table 15. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 80% Rural Model

NORMALIZED TO A NUMBER DENSITY OF 1.5000E+04 PARTICLES/CM3					
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	4.649E-01	3.484E-01	1.165E-01	.7494	.7725
.300	3.849E-01	3.663E-01	1.859E-02	.9517	.7240
.337	3.546E-01	3.416E-01	1.306E-02	.9632	.7197
.550	2.245E-01	2.153E-01	9.161E-03	.9592	.6997
.694	1.700E-01	1.620E-01	8.011E-03	.9531	.6858
1.060	9.704E-02	8.771E-02	9.329E-03	.9039	.6650
1.536	5.690E-02	4.877E-02	8.132E-03	.8571	.6702
2.000	3.695E-02	3.355E-02	3.402E-03	.9079	.7181
2.250	3.295E-02	2.962E-02	3.331E-03	.8989	.7378
2.500	2.970E-02	2.604E-02	3.668E-03	.8765	.7653
2.700	3.009E-02	1.824E-02	1.186E-02	.6060	.8168
3.000	4.561E-02	1.487E-02	3.074E-02	.3261	.7661
3.392	2.890E-02	2.330E-02	5.600E-03	.8062	.7286
3.750	2.582E-02	2.384E-02	1.985E-03	.9231	.7336
4.500	2.353E-02	1.948E-02	4.055E-03	.8277	.7654
5.000	2.180E-02	1.825E-02	3.548E-03	.8372	.7735
5.500	2.001E-02	1.625E-02	3.760E-03	.8121	.7910
6.000	2.105E-02	1.023E-02	1.082E-02	.4861	.8303
6.200	2.180E-02	1.200E-02	9.802E-03	.5504	.8025
6.500	1.974E-02	1.298E-02	6.762E-03	.6574	.7957
7.200	1.931E-02	1.159E-02	7.726E-03	.6000	.7946
7.900	1.402E-02	7.448E-03	6.574E-03	.5312	.8468
8.200	1.257E-02	4.323E-03	8.251E-03	.3438	.8734
8.700	2.673E-02	1.278E-02	1.394E-02	.4783	.6831
9.000	2.827E-02	1.276E-02	1.551E-02	.4513	.6619
9.200	2.772E-02	1.093E-02	1.679E-02	.3944	.6994
10.000	1.962E-02	1.088E-02	8.749E-03	.5544	.7250
10.591	1.729E-02	9.450E-03	7.841E-03	.5465	.7449
11.000	1.632E-02	8.427E-03	7.890E-03	.5164	.7547
11.300	1.581E-02	6.903E-03	8.912E-03	.4365	.7665
12.500	1.671E-02	5.142E-03	1.157E-02	.3077	.7644
14.800	1.828E-02	4.273E-03	1.401E-02	.2337	.7265
15.000	1.978E-02	4.197E-03	1.558E-02	.2122	.7170
16.400	1.922E-02	5.300E-03	1.392E-02	.2757	.6769
17.200	2.012E-02	6.169E-03	1.395E-02	.3067	.6409
18.500	1.808E-02	5.478E-03	1.260E-02	.3030	.6442
21.300	1.723E-02	5.530E-03	1.170E-02	.3210	.6031
25.000	1.494E-02	4.605E-03	1.034E-02	.3081	.5854
30.000	1.290E-02	3.487E-03	9.416E-03	.2702	.5646
40.000	1.164E-02	2.451E-03	9.188E-03	.2106	.4977

Table 16. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 90% Rural Model

NORMALIZED TO A NUMBER DENSITY OF 1.5000E+04 PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	6.745E-01	5.419E-01	1.326E-01	.8034	.7759
.300	5.637E-01	5.444E-01	1.933E-02	.9657	.7505
.337	5.240E-01	5.104E-01	1.360E-02	.9740	.7473
.550	3.409E-01	3.314E-01	9.549E-03	.9720	.7311
.694	2.621E-01	2.538E-01	8.334E-03	.9682	.7178
1.060	1.507E-01	1.408E-01	9.905E-03	.9343	.6934
1.536	8.808E-02	7.939E-02	8.694E-03	.9013	.6873
2.000	5.785E-02	5.384E-02	4.010E-03	.9307	.7167
2.250	5.046E-02	4.686E-02	3.601E-03	.9285	.7338
2.500	4.447E-02	4.007E-02	4.400E-03	.9010	.7628
2.700	4.333E-02	2.676E-02	1.657E-02	.6176	.6252
3.000	8.680E-02	2.353E-02	6.327E-02	.2711	.7289
3.392	4.597E-02	3.577E-02	1.020E-02	.7781	.7101
3.750	3.929E-02	3.637E-02	2.924E-03	.9256	.7248
4.500	3.551E-02	2.895E-02	6.556E-03	.8154	.7662
5.000	3.291E-02	2.723E-02	5.680E-03	.8274	.7760
5.500	3.008E-02	2.450E-02	5.580E-03	.8145	.7964
6.000	3.484E-02	1.443E-02	2.041E-02	.4141	.8369
6.200	3.570E-02	1.774E-02	1.796E-02	.4971	.8024
6.500	3.076E-02	1.972E-02	1.104E-02	.6412	.7988
7.200	2.890E-02	1.787E-02	1.103E-02	.6182	.8039
7.900	2.315E-02	1.339E-02	9.758E-03	.5784	.8425
8.200	2.131E-02	9.900E-03	1.141E-02	.4645	.8643
8.700	3.572E-02	1.784E-02	1.788E-02	.4994	.7340
9.000	3.768E-02	1.769E-02	1.999E-02	.4695	.7185
9.200	3.652E-02	1.527E-02	2.125E-02	.4181	.7489
10.000	2.661E-02	1.429E-02	1.233E-02	.5369	.7768
10.591	2.378E-02	1.175E-02	1.203E-02	.4940	.7970
11.000	2.318E-02	9.879E-03	1.330E-02	.4262	.8062
11.500	2.373E-02	7.756E-03	1.597E-02	.3268	.8121
12.500	2.835E-02	6.138E-03	2.221E-02	.2156	.7944
14.800	3.317E-02	6.348E-03	2.682E-02	.1914	.7402
15.000	3.469E-02	6.396E-03	2.829E-02	.1844	.7321
16.400	3.348E-02	7.476E-03	2.600E-02	.2233	.6999
17.200	3.370E-02	8.371E-03	2.533E-02	.2484	.6741
18.500	3.103E-02	7.825E-03	2.320E-02	.2522	.6696
21.300	2.822E-02	7.858E-03	2.036E-02	.2785	.6368
25.000	2.448E-02	6.839E-03	1.764E-02	.2793	.6164
30.000	2.086E-02	5.486E-03	1.538E-02	.2629	.5945
40.000	1.846E-02	3.833E-03	1.463E-02	.2076	.5344

Table 17. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 95% Rural Model

NORMALIZED TO A NUMBER DENSITY OF 1.5000E+04 PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	8.142E-01	6.737E-01	1.405E-01	.8274	.7758
.300	6.894E-01	6.696E-01	1.977E-02	.9713	.7606
.337	6.436E-01	6.297E-01	1.385E-02	.9785	.7581
.550	4.271E-01	4.174E-01	9.725E-03	.9772	.7438
.694	3.315E-01	3.230E-01	8.510E-03	.9743	.7312
1.060	1.923E-01	1.821E-01	1.018E-02	.9471	.7062
1.536	1.126E-01	1.036E-01	9.010E-03	.9200	.6956
2.000	7.427E-02	6.979E-02	4.478E-03	.9397	.7168
2.250	6.409E-02	6.030E-02	3.792E-03	.9408	.7322
2.500	5.576E-02	5.081E-02	4.945E-03	.9113	.7625
2.700	5.331E-02	3.319E-02	2.012E-02	.6225	.8276
3.000	1.175E-01	3.071E-02	8.684E-02	.2612	.7130
3.392	5.911E-02	4.545E-02	1.366E-02	.7689	.7014
3.750	4.952E-02	4.586E-02	3.655E-03	.9262	.7198
4.500	4.452E-02	3.605E-02	8.472E-03	.8097	.7648
5.000	4.126E-02	3.395E-02	7.320E-03	.8226	.7755
5.500	3.766E-02	3.068E-02	6.984E-03	.8146	.7974
6.000	4.517E-02	1.772E-02	2.746E-02	.3922	.6782
6.200	4.605E-02	2.207E-02	2.397E-02	.4794	.8012
6.500	3.903E-02	2.476E-02	1.427E-02	.6343	.7993
7.200	3.616E-02	2.261E-02	1.355E-02	.6253	.8072
7.900	3.006E-02	1.787E-02	1.219E-02	.5945	.8407
8.200	2.806E-02	1.423E-02	1.382E-02	.5074	.8600
8.700	4.208E-02	2.154E-02	2.054E-02	.5120	.7563
9.000	4.410E-02	2.125E-02	2.286E-02	.4818	.7441
9.200	4.263E-02	1.851E-02	2.412E-02	.4342	.7724
10.000	3.183E-02	1.683E-02	1.500E-02	.5286	.7983
10.591	2.869E-02	1.350E-02	1.519E-02	.4706	.8186
11.000	2.844E-02	1.109E-02	1.735E-02	.3898	.8263
11.500	2.985E-02	8.622E-03	2.123E-02	.2888	.8294
12.500	3.730E-02	7.217E-03	3.008E-02	.1935	.8056
14.800	4.434E-02	8.076E-03	3.626E-02	.1822	.7474
15.000	4.585E-02	8.173E-03	3.767E-02	.1783	.7401
16.400	4.425E-02	9.291E-03	3.496E-02	.2100	.7106
17.200	4.403E-02	1.019E-02	3.384E-02	.2315	.6886
18.500	4.082E-02	9.739E-03	3.108E-02	.2386	.6817
21.300	3.656E-02	9.715E-03	2.684E-02	.2657	.6928
25.000	3.174E-02	8.615E-03	2.312E-02	.2714	.6318
30.000	2.696E-02	7.084E-03	1.987E-02	.2628	.6099
40.000	2.367E-02	4.953E-03	1.872E-02	.2093	.5529

Table 18. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 98% Rural Model

	NORMALIZED TO A NUMBER DENSITY OF 1.0000E+04 PARTICLES/CM3				
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	1.058E+00	8.998E-01	1.580E-01	.8507	.7773
.300	9.201E-01	8.987E-01	2.142E-02	.9767	.7726
.337	8.659E-01	8.512E-01	1.474E-02	.9830	.7712
.550	5.990E-01	5.888E-01	1.025E-02	.9829	.7612
.694	4.755E-01	4.665E-01	8.992E-03	.9811	.7900
1.060	2.898E-01	2.789E-01	1.009E-02	.9624	.7387
1.536	1.801E-01	1.703E-01	9.851E-03	.9453	.7227
2.000	1.270E-01	1.212E-01	5.800E-03	.9544	.7396
2.250	1.127E-01	1.081E-01	4.582E-03	.9593	.7837
2.500	1.001E-01	9.265E-02	7.457E-03	.9255	.7853
2.700	9.412E-02	6.078E-02	3.334E-02	.6457	.8590
3.000	1.942E-01	5.532E-02	1.389E-01	.2848	.7444
3.392	1.074E-01	8.017E-02	2.723E-02	.7465	.7222
3.750	9.282E-02	8.567E-02	7.157E-03	.9229	.7344
4.500	8.545E-02	6.853E-02	1.692E-02	.8020	.7867
5.000	8.098E-02	6.626E-02	1.473E-02	.8181	.7995
5.500	7.556E-02	6.213E-02	1.343E-02	.8222	.8167
6.000	8.532E-02	3.509E-02	5.023E-02	.4113	.8657
6.200	8.833E-02	4.346E-02	4.487E-02	.4920	.8262
6.500	7.790E-02	5.039E-02	2.751E-02	.6468	.8283
7.200	7.237E-02	4.807E-02	2.430E-02	.6642	.8300
7.900	6.510E-02	4.245E-02	2.265E-02	.6520	.8580
8.200	6.262E-02	3.846E-02	2.416E-02	.6142	.8628
8.700	7.288E-02	4.211E-02	3.077E-02	.5778	.8198
9.000	7.407E-02	4.076E-02	3.331E-02	.5503	.8159
9.200	7.180E-02	3.713E-02	3.467E-02	.5171	.8312
10.000	5.774E-02	3.185E-02	2.589E-02	.5516	.8541
10.591	5.196E-02	2.443E-02	2.753E-02	.4702	.8710
11.000	5.143E-02	1.920E-02	3.223E-02	.3733	.8764
11.500	5.433E-02	1.516E-02	3.917E-02	.2790	.8744
12.500	6.923E-02	1.496E-02	5.427E-02	.2161	.8475
14.800	8.346E-02	1.871E-02	6.475E-02	.2242	.7836
15.000	8.504E-02	1.897E-02	6.608E-02	.2230	.7784
16.400	8.350E-02	2.053E-02	6.297E-02	.2459	.7534
17.200	8.266E-02	2.153E-02	6.113E-02	.2605	.7389
18.500	7.878E-02	2.154E-02	5.724E-02	.2734	.7269
21.300	7.127E-02	2.124E-02	5.003E-02	.2980	.7049
25.000	6.371E-02	1.976E-02	4.395E-02	.3101	.6825
30.000	5.532E-02	1.732E-02	3.800E-02	.3132	.6600
40.000	4.786E-02	1.243E-02	3.543E-02	.2598	.6112

Table 19. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 99% Rural Model

NORMALIZED TO A NUMBER DENSITY OF 1.5000E+04 PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	1.300E+00	1.128E+00	1.710E-01	.8679	.7770
.300	1.158E+00	1.135E+00	2.227E-02	.9808	.7793
.337	1.097E+00	1.082E+00	1.521E-02	.9861	.7786
.550	7.828E-01	7.724E-01	1.050E-02	.9866	.7717
.694	6.314E-01	6.222E-01	9.156E-03	.9855	.7628
1.060	3.961E-01	3.849E-01	1.125E-02	.9716	.7444
1.536	2.529E-01	2.422E-01	1.038E-02	.9589	.7365
2.000	1.837E-01	1.747E-01	9.016E-03	.9509	.7491
2.250	1.626E-01	1.572E-01	5.433E-03	.9666	.7609
2.500	1.451E-01	1.347E-01	1.040E-02	.9283	.7921
2.700	1.358E-01	8.799E-02	4.780E-02	.6480	.8688
3.000	2.749E-01	8.163E-02	1.933E-01	.2969	.7577
3.392	1.566E-01	1.149E-01	4.169E-02	.7339	.7294
3.750	1.361E-01	1.249E-01	1.121E-02	.9176	.7413
4.500	1.263E-01	1.000E-01	2.633E-02	.7916	.7928
5.000	1.208E-01	9.769E-02	2.307E-02	.8090	.8016
5.500	1.139E-01	9.315E-02	2.078E-02	.8176	.8225
6.000	1.269E-01	5.303E-02	7.390E-02	.4178	.8761
6.200	1.312E-01	6.463E-02	6.660E-02	.4925	.8759
6.500	1.174E-01	7.552E-02	4.187E-02	.6433	.8285
7.200	1.099E-01	7.363E-02	3.623E-02	.6702	.8385
7.900	1.019E-01	6.725E-02	3.429E-02	.6623	.8599
8.200	9.863E-02	6.296E-02	3.567E-02	.6384	.8654
8.700	1.061E-01	6.398E-02	4.212E-02	.6030	.8414
9.000	1.063E-01	6.158E-02	4.474E-02	.5792	.8415
9.200	1.036E-01	5.740E-02	4.617E-02	.5542	.8527
10.000	8.665E-02	4.860E-02	3.805E-02	.5608	.8740
10.591	7.822E-02	3.711E-02	4.111E-02	.4744	.8933
11.000	7.731E-02	2.902E-02	4.829E-02	.3754	.8952
11.500	8.157E-02	2.335E-02	5.822E-02	.2863	.8923
12.500	1.037E-01	2.421E-02	7.945E-02	.2336	.8611
14.800	1.247E-01	3.059E-02	9.411E-02	.2451	.8233
15.000	1.263E-01	3.092E-02	9.541E-02	.2448	.7989
16.400	1.249E-01	3.303E-02	9.185E-02	.2645	.7758
17.200	1.235E-01	3.421E-02	8.932E-02	.2769	.7632
18.500	1.189E-01	3.461E-02	8.426E-02	.2912	.7528
21.300	1.084E-01	3.414E-02	7.426E-02	.3149	.7314
25.000	9.835E-02	3.237E-02	6.597E-02	.3292	.7091
30.000	8.671E-02	2.918E-02	5.754E-02	.3365	.6867
40.000	7.517E-02	2.148E-02	5.369E-02	.2857	.6419

Table 20. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 0% Urban Model

NORMALIZED TO A NUMBER DENSITY OF 2.0000E+04 PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	3.336E-01	1.950E-01	1.386E-01	.5846	.7705
.300	2.885E-01	1.843E-01	1.042E-01	.6389	.7182
.337	2.683E-01	1.724E-01	9.591E-02	.6426	.7067
.550	1.767E-01	1.127E-01	6.393E-02	.6382	.6617
.694	1.374E-01	8.579E-02	5.163E-02	.6243	.6413
1.060	8.320E-02	4.630E-02	3.690E-02	.5565	.6166
1.536	5.302E-02	2.535E-02	2.766E-02	.4782	.6287
2.000	3.779E-02	1.601E-02	2.178E-02	.4237	.6883
2.250	3.429E-02	1.404E-02	2.025E-02	.4095	.7070
2.500	3.160E-02	1.261E-02	1.899E-02	.3991	.7243
2.700	3.202E-02	1.118E-02	2.084E-02	.3491	.7370
3.000	2.850E-02	1.079E-02	1.771E-02	.3787	.7446
3.392	2.612E-02	1.065E-02	1.547E-02	.4076	.7391
3.750	2.474E-02	1.028E-02	1.446E-02	.4155	.7371
4.500	2.247E-02	9.203E-03	1.326E-02	.4097	.7414
5.000	2.099E-02	8.614E-03	1.237E-02	.4104	.7435
5.500	1.984E-02	7.933E-03	1.191E-02	.3998	.7466
6.000	1.873E-02	7.067E-03	1.166E-02	.3773	.7543
6.200	1.855E-02	6.987E-03	1.157E-02	.3766	.7498
6.500	1.830E-02	6.903E-03	1.140E-02	.3772	.7424
7.200	1.827E-02	6.501E-03	1.177E-02	.3558	.7270
7.900	1.548E-02	4.391E-03	1.109E-02	.2836	.7674
8.200	1.528E-02	3.005E-03	1.228E-02	.1966	.7850
8.700	2.109E-02	8.154E-03	1.293E-02	.3867	.5880
9.000	2.144E-02	8.253E-03	1.319E-02	.3849	.5616
9.200	2.173E-02	7.419E-03	1.431E-02	.3414	.5901
10.000	1.732E-02	7.153E-03	1.016E-02	.4131	.6159
10.591	1.601E-02	6.696E-03	9.311E-03	.4183	.6238
11.000	1.519E-02	6.531E-03	8.656E-03	.4300	.6240
11.500	1.448E-02	6.115E-03	8.365E-03	.4223	.6281
12.500	1.337E-02	5.427E-03	7.939E-03	.4061	.6306
14.800	1.184E-02	3.982E-03	7.854E-03	.3364	.6298
15.000	1.274E-02	3.672E-03	9.064E-03	.2883	.6252
16.400	1.209E-02	4.408E-03	7.685E-03	.3645	.5785
17.200	1.268E-02	4.831E-03	7.848E-03	.3810	.5378
18.500	1.123E-02	4.167E-03	7.059E-03	.3712	.5512
21.300	1.092E-02	3.886E-03	7.032E-03	.3559	.5072
25.000	9.495E-03	3.079E-03	6.415E-03	.3243	.4930
30.000	8.359E-03	2.236E-03	6.123E-03	.2675	.4709
40.000	7.151E-03	1.598E-03	5.554E-03	.2234	.4009

Table 21. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 50% Urban Model

NORMALIZED TO A NUMBER DENSITY OF 2.0000E+04 PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	3.516E-01	2.091E-01	1.425E-01	.5947	.7811
.300	3.026E-01	1.964E-01	1.063E-01	.6488	.7236
.337	2.813E-01	1.835E-01	9.774E-02	.6525	.7126
.550	1.848E-01	1.199E-01	6.498E-02	.6484	.6685
.694	1.437E-01	9.118E-02	5.252E-02	.6345	.6482
1.060	8.688E-02	4.928E-02	3.761E-02	.5672	.6231
1.536	5.527E-02	2.705E-02	2.822E-02	.4893	.6342
2.000	3.939E-02	1.718E-02	2.222E-02	.4361	.6919
2.250	3.570E-02	1.507E-02	2.064E-02	.4220	.7106
2.500	3.287E-02	1.350E-02	1.937E-02	.4107	.7286
2.700	3.324E-02	1.182E-02	2.142E-02	.3557	.7440
3.000	3.143E-02	1.125E-02	2.018E-02	.3579	.7453
3.392	2.748E-02	1.155E-02	1.593E-02	.4203	.7388
3.750	2.587E-02	1.110E-02	1.477E-02	.4292	.7392
4.500	2.349E-02	9.881E-03	1.361E-02	.4207	.7455
5.000	2.193E-02	9.248E-03	1.268E-02	.4217	.7480
5.500	2.070E-02	8.501E-03	1.220E-02	.4106	.7519
6.000	1.980E-02	7.427E-03	1.237E-02	.3751	.7611
6.200	1.964E-02	7.474E-03	1.217E-02	.3805	.7540
6.500	1.918E-02	7.404E-03	1.178E-02	.3859	.7476
7.200	1.908E-02	6.943E-03	1.213E-02	.3640	.7338
7.900	1.614E-02	4.750E-03	1.139E-02	.2943	.7728
8.200	1.584E-02	3.285E-03	1.256E-02	.2074	.7908
8.700	2.218E-02	8.617E-03	1.356E-02	.3885	.6008
9.000	2.263E-02	8.723E-03	1.391E-02	.3854	.5753
9.200	2.285E-02	7.809E-03	1.504E-02	.3418	.6038
10.000	1.812E-02	7.512E-03	1.060E-02	.4147	.6290
10.591	1.673E-02	6.989E-03	9.742E-03	.4177	.6375
11.000	1.589E-02	6.767E-03	9.127E-03	.4257	.6385
11.500	1.520E-02	6.276E-03	8.925E-03	.4129	.6432
12.500	1.421E-02	5.482E-03	8.724E-03	.3859	.6454
14.800	1.288E-02	4.066E-03	8.899E-03	.3158	.6387
15.060	1.381E-02	3.791E-03	1.002E-02	.2746	.6331
16.400	1.311E-02	4.532E-03	8.574E-03	.3458	.5684
17.200	1.367E-02	4.998E-03	8.672E-03	.3656	.5489
18.500	1.216E-02	4.322E-03	7.843E-03	.3553	.5603
21.300	1.175E-02	4.076E-03	7.676E-03	.3468	.5166
25.000	1.022E-02	3.252E-03	6.969E-03	.3182	.5016
30.000	8.970E-03	2.382E-03	6.588E-03	.2655	.4791
40.000	7.696E-03	1.699E-03	5.997E-03	.2208	.4101

Table 22. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 70% Urban Model

NORMALIZED TO A NUMBER DENSITY OF 2.0000E+04 PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	4.640E-01	3.000E-01	1.641E-01	.6471	.7906
.300	3.921E-01	2.748E-01	1.173E-01	.7008	.7476
.337	3.630E-01	2.564E-01	1.073E-01	.7049	.7385
.550	2.377E-01	1.670E-01	7.069E-02	.7026	.6998
.694	1.845E-01	1.272E-01	5.721E-02	.6899	.6803
1.060	1.108E-01	6.950E-02	4.135E-02	.6270	.6536
1.536	7.008E-02	3.884E-02	3.125E-02	.5542	.6590
2.000	5.002E-02	2.541E-02	2.461E-02	.5080	.7066
2.250	4.502E-02	2.223E-02	2.279E-02	.4937	.7258
2.500	4.107E-02	1.962E-02	2.145E-02	.4777	.7484
2.700	4.090E-02	1.615E-02	2.475E-02	.3950	.7769
3.000	5.090E-02	1.501E-02	3.589E-02	.2950	.7405
3.392	3.649E-02	1.776E-02	1.873E-02	.4867	.7351
3.750	3.339E-02	1.688E-02	1.651E-02	.5055	.7459
4.500	3.024E-02	1.462E-02	1.562E-02	.4835	.7625
5.000	2.819E-02	1.370E-02	1.449E-02	.4860	.7673
5.500	2.635E-02	1.249E-02	1.386E-02	.4740	.7759
6.000	2.692E-02	9.880E-03	1.704E-02	.3670	.7910
6.200	2.691E-02	1.076E-02	1.616E-02	.3997	.7732
6.500	2.511E-02	1.092E-02	1.419E-02	.4348	.7703
7.200	[illegible].435E-02	1.006E-02	1.430E-02	.4139	.7644
7.900	2.066E-02	7.385E-03	1.328E-02	.3574	.7966
8.200	1.987E-02	5.497E-03	1.438E-02	.2766	.8142
8.700	2.855E-02	1.158E-02	1.697E-02	.4055	.6635
9.000	2.951E-02	1.170E-02	1.781E-02	.3964	.6428
9.200	2.924E-02	1.032E-02	1.891E-02	.3532	.6730
10.000	2.285E-02	9.721E-03	1.313E-02	.4255	.6935
10.591	2.102E-02	8.701E-03	1.232E-02	.4146	.7050
11.000	2.017E-02	8.078E-03	1.209E-02	.4005	.7092
11.500	1.969E-02	7.125E-03	1.257E-02	.3618	.7145
12.500	1.987E-02	5.888E-03	1.399E-02	.2962	.7094
14.800	2.004E-02	4.876E-03	1.516E-02	.2434	.6762
15.000	2.110E-02	4.756E-03	1.635E-02	.2254	.6684
16.400	2.008E-02	5.525E-03	1.456E-02	.2751	.6316
17.200	2.045E-02	6.148E-03	1.430E-02	.3007	.5997
18.500	1.862E-02	5.488E-03	1.313E-02	.2948	.6013
21.300	1.740E-02	5.350E-03	1.205E-02	.3075	.5625
25.000	1.513E-02	4.438E-03	1.069E-02	.2934	.5433
30.000	1.290E-02	3.396E-03	9.680E-03	.2597	.5198
40.000	1.129E-02	2.397E-03	8.892E-03	.2123	.4552

Table 23. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 80% Urban Model

NORMALIZED TO A NUMBER DENSITY OF 2.0000E+04 PARTICLES/CM3					
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	7.075E-01	5.099E-01	1.976E-01	.7208	.7949
.300	5.908E-01	4.572E-01	1.336E-01	.7738	.7713
.337	5.489E-01	4.274E-01	1.215E-01	.7786	.7650
.550	3.602E-01	2.811E-01	7.906E-02	.7805	.7342
.694	2.799E-01	2.158E-01	6.407E-02	.7711	.7162
1.060	1.666E-01	1.199E-01	4.670E-02	.7197	.6873
1.536	1.073E-01	6.784E-02	3.950E-02	.6365	.6820
2.000	7.316E-02	4.505E-02	2.811E-02	.6158	.7131
2.250	6.477E-02	3.896E-02	2.581E-02	.6015	.7312
2.500	5.799E-02	3.353E-02	2.446E-02	.5782	.7503
2.700	5.624E-02	2.540E-02	3.083E-02	.4517	.8030
3.000	9.536E-02	2.463E-02	7.073E-02	.2583	.7171
3.392	5.566E-02	3.144E-02	2.421E-02	.5650	.7185
3.750	4.886E-02	2.971E-02	1.915E-02	.6081	.7400
4.500	4.401E-02	2.486E-02	1.915E-02	.5648	.7698
5.000	4.092E-02	2.332E-02	1.760E-02	.5699	.7778
5.500	3.781E-02	2.116E-02	1.665E-02	.5597	.7923
6.000	4.219E-02	1.492E-02	2.727E-02	.3536	.8142
6.200	4.233E-02	1.748E-02	2.484E-02	.4131	.7864
6.500	3.744E-02	1.838E-02	1.907E-02	.4908	.7867
7.200	3.517E-02	1.679E-02	1.838E-02	.4775	.7891
7.900	3.040E-02	1.336E-02	1.704E-02	.4394	.8147
8.200	2.901E-02	1.091E-02	1.810E-02	.3760	.8298
8.700	3.941E-02	1.719E-02	2.222E-02	.4362	.7276
9.000	4.085E-02	1.718E-02	2.367E-02	.4205	.7136
9.200	3.985E-02	1.517E-02	2.468E-02	.3806	.7361
10.000	3.134E-02	1.372E-02	1.762E-02	.4379	.7590
10.591	2.890E-02	1.163E-02	1.727E-02	.4024	.7729
11.000	2.840E-02	1.019E-02	1.820E-02	.3589	.7783
11.500	2.892E-02	8.519E-03	2.040E-02	.2946	.7608
12.500	3.278E-02	7.110E-03	2.567E-02	.2169	.7624
14.800	3.626E-02	7.114E-03	2.915E-02	.1962	.7094
15.000	3.742E-02	7.129E-03	3.029E-02	.1905	.7022
16.400	3.582E-02	7.985E-03	2.783E-02	.2229	.6714
17.200	3.562E-02	8.704E-03	2.691E-02	.2444	.6480
18.500	3.297E-02	8.171E-03	2.480E-02	.2479	.6417
21.300	2.970E-02	8.021E-03	2.168E-02	.2701	.6104
25.000	2.576E-02	6.953E-03	1.881E-02	.2699	.5887
30.000	2.193E-02	5.595E-03	1.633E-02	.2551	.5651
40.000	1.892E-02	3.904E-03	1.501E-02	.2064	.5058

Table 24. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 90% Urban Model

NORMALIZED TO A NUMBER DENSITY OF 2.0000E+04 PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	1.044E+00	8.140E-01	2.295E-01	.7803	.7924
.300	8.851E-01	7.356E-01	1.494E-01	.8311	.7847
.337	8.276E-01	6.921E-01	1.355E-01	.8362	.7807
.550	5.563E-01	4.685E-01	8.781E-02	.8422	.7574
.694	4.361E-01	3.649E-01	7.126E-02	.8366	.7417
1.060	2.604E-01	2.082E-01	5.227E-02	.7993	.7128
1.536	1.595E-01	1.196E-01	3.988E-02	.7500	.6999
2.000	1.119E-01	7.999E-02	3.194E-02	.7146	.7175
2.250	9.744E-02	6.850E-02	2.894E-02	.7030	.7330
2.500	8.551E-02	5.769E-02	2.781E-02	.6747	.7619
2.700	8.062E-02	4.085E-02	3.977E-02	.5067	.8183
3.000	1.667E-01	4.178E-02	1.250E-01	.2506	.6984
3.392	8.728E-02	5.466E-02	3.262E-02	.6262	.7031
3.750	7.397E-02	5.167E-02	2.229E-02	.6986	.7301
4.500	6.622E-02	4.200E-02	2.422E-02	.6342	.7696
5.000	6.153E-02	3.950E-02	2.202E-02	.6421	.7800
5.500	5.649E-02	3.594E-02	2.055E-02	.6363	.7993
6.000	6.691E-02	2.327E-02	4.364E-02	.3478	.8272
6.200	6.724E-02	2.840E-02	3.883E-02	.4224	.7927
6.500	5.756E-02	3.077E-02	2.679E-02	.5346	.7950
7.200	5.292E-02	2.829E-02	2.462E-02	.5347	.8035
7.900	4.682E-02	2.384E-02	2.298E-02	.5092	.8249
8.200	4.482E-02	2.080E-02	2.402E-02	.4641	.8373
8.700	5.513E-02	2.621E-02	2.893E-02	.4753	.7736
9.000	5.655E-02	2.576E-02	3.079E-02	.4556	.7660
9.200	5.487E-02	2.309E-02	3.178E-02	.4208	.7831
10.000	4.434E-02	2.010E-02	2.423E-02	.4534	.8054
10.591	4.110E-02	1.623E-02	2.488E-02	.3948	.8201
11.000	4.136E-02	1.354E-02	2.783E-02	.3272	.8249
11.500	4.382E-02	1.100E-02	3.282E-02	.2510	.8239
12.500	5.412E-02	9.895E-03	4.423E-02	.1828	.7957
14.800	6.271E-02	1.137E-02	5.135E-02	.1812	.7351
15.000	6.389E-02	1.148E-02	5.241E-02	.1797	.7291
16.400	6.197E-02	1.294E-02	4.903E-02	.2087	.7020
17.200	6.049E-02	1.333E-02	4.716E-02	.2203	.6843
18.500	5.648E-02	1.299E-02	4.349E-02	.2300	.6742
21.300	4.988E-02	1.269E-02	3.719E-02	.2544	.6491
25.000	4.332E-02	1.138E-02	3.194E-02	.2627	.6268
30.000	3.668E-02	9.535E-03	2.714E-02	.2600	.6036
40.000	3.155E-02	6.655E-03	2.489E-02	.2110	.5493

Table 25. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 95% Urban Model

NORMALIZED TO A NUMBER DENSITY OF 2.0000E+04 PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	1.473E+00	1.214E+00	2.592E-01	.8241	.7883
.300	1.286E+00	1.121E+00	1.655E-01	.8713	.7922
.337	1.213E+00	1.063E+00	1.498E-01	.8765	.7897
.550	8.457E-01	7.487E-01	9.707E-02	.8852	.7730
.694	6.731E-01	5.942E-01	7.888E-02	.8828	.7597
1.060	4.089E-01	3.508E-01	5.803E-02	.8581	.7328
1.536	2.505E-01	2.061E-01	4.440E-02	.8228	.7160
2.000	1.751E-01	1.380E-01	3.628E-02	.7928	.7241
2.250	1.505E-01	1.183E-01	3.219E-02	.7861	.7365
2.500	1.299E-01	9.807E-02	3.179E-02	.7552	.7650
2.700	1.194E-01	6.602E-02	5.339E-02	.5529	.8287
3.000	2.746E-01	7.041E-02	2.042E-01	.2564	.6912
3.392	1.384E-01	9.271E-02	4.573E-02	.6697	.6946
3.750	1.144E-01	8.809E-02	2.636E-02	.7697	.7224
4.500	1.019E-01	6.995E-02	3.199E-02	.6862	.7678
5.000	9.482E-02	6.604E-02	2.878E-02	.6965	.7798
5.500	8.699E-02	6.053E-02	2.646E-02	.6958	.8024
6.000	1.060E-01	3.713E-02	6.889E-02	.3502	.8358
6.200	1.067E-01	4.603E-02	6.069E-02	.4313	.7967
6.500	9.014E-02	5.101E-02	3.913E-02	.5659	.8000
7.200	8.210E-02	4.757E-02	3.453E-02	.5794	.8126
7.900	7.421E-02	4.171E-02	3.250E-02	.5620	.8318
8.200	7.149E-02	3.799E-02	3.350E-02	.5313	.8421
8.700	8.015E-02	4.140E-02	3.875E-02	.5165	.8058
9.000	8.097E-02	4.009E-02	4.087E-02	.4952	.8033
9.200	7.862E-02	3.670E-02	4.192E-02	.4668	.8160
10.000	6.563E-02	3.103E-02	3.460E-02	.4728	.8377
10.591	6.107E-02	2.419E-02	3.688E-02	.3961	.8527
11.000	6.242E-02	1.951E-02	4.291E-02	.3125	.8560
11.500	6.781E-02	1.577E-02	5.204E-02	.2326	.8534
12.500	8.789E-02	1.544E-02	7.245E-02	.1756	.8200
14.000	1.040E-01	1.901E-02	8.500E-02	.1828	.7582
15.000	1.052E-01	1.924E-02	8.596E-02	.1829	.7531
16.400	1.020E-01	2.068E-02	8.131E-02	.2027	.7287
17.200	9.973E-02	2.158E-02	7.815E-02	.2163	.7145
18.500	9.371E-02	2.151E-02	7.220E-02	.2295	.7031
21.300	8.228E-02	2.096E-02	6.132E-02	.2547	.6825
25.000	7.191E-02	1.928E-02	5.262E-02	.2682	.6604
30.000	6.112E-02	1.671E-02	4.441E-02	.2733	.6379
40.000	5.253E-02	1.182E-02	4.071E-02	.2250	.5883

Table 26. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 98% Urban Model

NORMALIZED TO A NUMBER DENSITY OF 2.0000E+04 PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	2.259E+00	1.957E+00	3.023E-01	.8662	.7834
.300	2.070E+00	1.880E+00	1.906E-01	.9080	.7974
.337	1.979E+00	1.807E+00	1.722E-01	.9130	.7966
.550	1.465E+00	1.354E+00	1.114E-01	.9240	.7874
.694	1.190E+00	1.100E+00	9.033E-02	.9246	.7775
1.060	7.590E-01	6.925E-01	6.647E-02	.9124	.7550
1.536	4.745E-01	4.236E-01	5.088E-02	.8928	.7371
2.000	3.344E-01	2.900E-01	4.433E-02	.8674	.7376
2.250	2.849E-01	2.476E-01	3.728E-02	.8691	.7461
2.500	2.424E-01	2.025E-01	3.963E-02	.8357	.7724
2.700	2.171E-01	1.297E-01	8.731E-02	.5978	.8415
3.000	5.200E-01	1.434E-01	3.765E-01	.2759	.6984
3.392	2.679E-01	1.890E-01	7.888E-02	.7056	.6951
3.750	2.178E-01	1.821E-01	3.565E-02	.8363	.7195
4.500	1.931E-01	1.409E-01	5.217E-02	.7298	.7682
5.000	1.805E-01	1.341E-01	4.645E-02	.7427	.7806
5.500	1.667E-01	1.247E-01	4.198E-02	.7482	.8054
6.000	2.034E-01	7.412E-02	1.293E-01	.3644	.8472
6.200	2.054E-01	9.138E-02	1.140E-01	.4449	.8037
6.500	1.742E-01	1.031E-01	7.106E-02	.5921	.8069
7.200	1.592E-01	9.865E-02	6.056E-02	.6196	.8227
7.900	1.476E-01	8.991E-02	5.769E-02	.6091	.8401
8.200	1.434E-01	8.489E-02	5.853E-02	.5919	.8487
8.700	1.476E-01	8.380E-02	6.384E-02	.5676	.8365
9.000	1.465E-01	8.030E-02	6.621E-02	.5481	.8387
9.200	1.430E-01	7.558E-02	6.744E-02	.5285	.8476
10.000	1.245E-01	6.283E-02	6.164E-02	.5048	.8687
10.591	1.158E-01	4.807E-02	6.774E-02	.4151	.8844
11.000	1.187E-01	3.795E-02	8.071E-02	.3199	.8884
11.500	1.299E-01	3.108E-02	9.886E-02	.2392	.8839
12.500	1.714E-01	3.275E-02	1.387E-01	.1910	.8489
14.000	2.048E-01	4.138E-02	1.634E-01	.2021	.7896
15.000	2.060E-01	4.185E-02	1.642E-01	.2031	.7856
16.400	2.014E-01	4.436E-02	1.571E-01	.2202	.7642
17.200	1.969E-01	4.562E-02	1.513E-01	.2317	.7531
18.500	1.868E-01	4.621E-02	1.405E-01	.2474	.7415
21.300	1.652E-01	4.518E-02	1.201E-01	.2734	.7253
25.000	1.468E-01	4.277E-02	1.041E-01	.2913	.7044
30.000	1.271E-01	3.856E-02	8.854E-02	.3034	.6829
40.000	1.099E-01	2.833E-02	8.159E-02	.2577	.6395

Table 27. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 99% Urban Model

	NORMALIZED TO A NUMBER DENSITY OF 2.0000E+04 PARTICLES/CM3				
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	2.987E+00	2.650E+00	3.379E-01	.8869	.7814
.300	2.830E+00	2.618E+00	2.115E-01	.9253	.7993
.337	2.730E+00	2.540E+00	1.906E-01	.9302	.7999
.550	2.115E+00	1.992E+00	1.224E-01	.9421	.7948
.694	1.769E+00	1.670E+00	9.882E-02	.9441	.7870
1.060	1.164E+00	1.091E+00	7.237E-02	.9378	.7682
1.536	7.474E-01	6.918E-01	5.562E-02	.9256	.7751
2.000	5.340E-01	4.814E-01	5.337E-02	.9002	.7501
2.250	4.562E-01	4.144E-01	4.177E-02	.9084	.7565
2.500	3.873E-01	3.375E-01	4.981E-02	.8714	.7609
2.700	3.429E-01	2.109E-01	1.320E-01	.6150	.8516
3.000	8.085E-01	2.361E-01	5.644E-01	.2950	.7137
3.392	4.334E-01	3.106E-01	1.229E-01	.7165	.7039
3.750	3.524E-01	3.041E-01	4.834E-02	.8628	.7241
4.500	3.126E-01	2.320E-01	8.055E-02	.7423	.7728
5.000	2.938E-01	2.221E-01	7.162E-02	.7562	.7846
5.500	2.737E-01	2.094E-01	6.434E-02	.7649	.8093
6.000	3.283E-01	1.248E-01	2.035E-01	.3800	.8576
6.200	3.322E-01	1.512E-01	1.810E-01	.4552	.8125
6.500	2.857E-01	1.714E-01	1.143E-01	.5999	.8140
7.200	2.639E-01	1.672E-01	9.677E-02	.6333	.8304
7.900	2.486E-01	1.557E-01	9.293E-02	.6262	.8472
8.200	2.430E-01	1.494E-01	9.357E-02	.6153	.8549
8.700	2.429E-01	1.442E-01	9.976E-02	.5935	.8525
9.000	2.396E-01	1.383E-01	1.013E-01	.5772	.8569
9.200	2.349E-01	1.322E-01	1.027E-01	.5627	.8640
10.000	2.097E-01	1.106E-01	9.934E-02	.5276	.8853
10.591	1.948E-01	8.528E-02	1.095E-01	.4378	.9017
11.000	1.976E-01	6.776E-02	1.3[illegible]E-01	.34[illegible]	[illegible]
11.500	2.140E-01	5.[illegible]E-02	1.[illegible]E-01	.26[illegible]	.9[illegible]
12.500	2.787E-01	5.995E-02	2.187E-01	.2152	.8685
14.000	3.319E-01	7.506E-02	2.569E-01	.2261	.8126
15.000	3.334E-01	7.583E-02	2.576E-01	.2274	.8091
16.400	3.280E-01	7.985E-02	2.482E-01	.2434	.7897
17.200	3.214E-01	8.167E-02	2.398E-01	.2541	.7802
18.500	3.074E-01	8.311E-02	2.243E-01	.2704	.7691
21.300	2.757E-01	8.177E-02	1.939E-01	.2966	.7550
25.000	2.492E-01	7.874E-02	1.705E-01	.3159	.7353
30.000	2.202E-01	7.284E-02	1.473E-01	.3309	.7146
40.000	1.924E-01	5.555E-02	1.369E-01	.2887	.6754

Table 28. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 0% Maritime Model

	NORMALIZED TO A NUMBER DENSITY OF 4000.			PARTICLES/CM3	
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	1.177E-01	9.299E-02	2.472E-02	.7900	.7516
.300	1.058E-01	1.023E-01	3.472E-03	.9672	.6960
.337	1.006E-01	9.834E-02	2.298E-03	.9772	.6920
.550	7.976E-02	7.833E-02	1.435E-03	.9820	.6756
.694	7.030E-02	6.912E-02	1.173E-03	.9833	.6767
1.060	5.607E-02	5.466E-02	1.408E-03	.9749	.6844
1.536	4.505E-02	4.379E-02	1.262E-03	.9720	.6936
2.000	3.669E-02	3.605E-02	6.493E-04	.9823	.7055
2.250	3.354E-02	3.262E-02	9.158E-04	.9727	.7112
2.500	3.056E-02	2.922E-02	1.339E-03	.9562	.7177
2.700	2.798E-02	2.534E-02	2.643E-03	.9055	.7367
3.000	3.371E-02	3.102E-02	2.694E-03	.9201	.6287
3.392	2.575E-02	2.518E-02	5.711E-04	.9778	.6779
3.750	2.298E-02	2.263E-02	3.543E-04	.9846	.6784
4.500	1.987E-02	1.947E-02	3.969E-04	.9800	.6599
5.000	1.690E-02	1.642E-02	4.800E-04	.9716	.6659
5.500	1.335E-02	1.275E-02	5.989E-04	.9551	.6859
6.000	1.180E-02	1.052E-02	1.272E-03	.8921	.6887
6.200	1.717E-02	1.483E-02	2.346E-03	.8634	.6095
6.500	1.203E-02	1.123E-02	7.925E-04	.9341	.6558
7.200	9.517E-03	8.528E-03	1.089E-03	.8858	.6665
7.900	8.005E-03	6.673E-03	1.332E-03	.8336	.6697
8.200	8.537E-03	6.511E-03	2.026E-03	.7627	.6594
8.700	1.202E-02	9.246E-03	2.776E-03	.7691	.5851
9.000	1.249E-02	9.778E-03	2.716E-03	.7826	.5644
9.200	1.168E-02	8.808E-03	2.870E-03	.7542	.5760
10.000	8.156E-03	6.872E-03	1.284E-03	.8425	.5903
10.591	6.674E-03	5.627E-03	1.046E-03	.8432	.5991
11.000	5.882E-03	4.965E-03	9.169E-04	.8441	.6024
11.500	5.445E-03	4.582E-03	8.628E-04	.8415	.5979
12.500	4.025E-03	3.171E-03	8.540E-04	.7878	.6307
14.800	3.491E-03	2.242E-03	1.249E-03	.6422	.5837
15.000	3.957E-03	2.312E-03	1.645E-03	.5843	.5763
16.400	4.914E-03	2.387E-03	2.527E-03	.4857	.5348
17.200	6.144E-03	3.104E-03	3.040E-03	.5052	.4955
18.500	5.770E-03	2.788E-03	2.982E-03	.4831	.4821
21.300	5.024E-03	1.992E-03	3.032E-03	.3965	.4635
25.000	4.372E-03	1.372E-03	3.000E-03	.3138	.4373
30.000	4.248E-03	8.920E-04	3.356E-03	.2100	.3944
40.000	6.971E-03	6.751E-04	6.296E-03	.0968	.2344

Table 29. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 50% Maritime Model

NORMALIZED TO A NUMBER DENSITY OF 4800. PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	1.258E-01	1.008E-01	2.499E-02	.8014	.7593
.300	1.136E-01	1.102E-01	3.440E-03	.9697	.7065
.337	1.090E-01	1.067E-01	2.300E-03	.9789	.7005
.550	8.685E-02	8.542E-02	1.430E-03	.9835	.6915
.694	7.744E-02	7.627E-02	1.173E-03	.9849	.6907
1.060	6.284E-02	6.143E-02	1.410E-03	.9776	.6980
1.536	5.096E-02	4.968E-02	1.275E-03	.9750	.7105
2.000	4.187E-02	4.114E-02	7.270E-04	.9826	.[illegible]227
2.250	3.821E-02	3.728E-02	9.309E-04	.9756	.7289
2.500	3.461E-02	3.320E-02	1.414E-03	.9592	.7380
2.700	3.098E-02	2.754E-02	3.438E-03	.8890	.7642
3.000	3.844E-02	2.766E-02	1.079E-02	.7197	.6953
3.392	3.057E-02	2.915E-02	1.423E-03	.9535	.6907
3.750	2.697E-02	2.648E-02	4.397E-04	.9818	.6919
4.500	2.299E-02	2.218E-02	8.110E-04	.9647	.6808
5.000	1.966E-02	1.885E-02	8.094E-04	.9588	.6851
5.500	1.561E-02	1.475E-02	8.612E-04	.9448	.7[illegible]32
6.000	1.416E-02	1.104E-02	3.123E-03	.7795	.7123
6.200	1.993E-02	1.606E-02	3.868E-03	.8059	.6382
6.500	1.431E-02	1.280E-02	1.517E-03	.8940	.6748
7.200	1.146E-02	9.856E-03	1.601E-03	.86[illegible]	.6833
7.900	9.549E-03	7.754E-03	1.796E-03	.8120	.6957
8.200	9.975E-03	7.501E-03	2.474E-03	.7520	.6768
8.700	1.341E-02	1.015E-02	3.254E-03	.7573	.6127
9.000	1.383E-02	1.061E-02	3.216E-03	.7674	.59[illegible]
9.200	1.293E-02	9.547E-03	3.381E-03	.7385	.6[illegible]55
10.000	9.109E-03	7.282E-03	1.827E-03	.7994	.6201
10.591	7.492E-03	5.790E-03	1.7[illegible]1E-03	.7729	.6291
11.000	6.727E-03	4.934E-03	1.7[illegible]E-03	.7335	.6327
11.500	6.401E-03	4.344E-03	2.0[illegible]E-03	.6786	.6291
12.500	5.559E-03	2.836E-03	2.72[illegible]E-03	.5102	.6298
14.800	5.691E-03	2.180E-03	3.510E-03	.3831	.5896
15.000	6.153E-03	2.265E-03	3.888E-03	.3681	.5829
16.400	7.025E-03	2.511E-03	4.514E-03	.3574	.5411
17.200	8.107E-03	3.250E-03	4.857E-03	.4009	.5379
18.500	7.635E-03	3.011E-03	4.624E-03	.3943	.4926
21.300	6.583E-03	2.267E-03	4.317E-03	.3443	.4715
25.000	5.653E-03	1.629E-03	4.024E-03	.2881	.4443
30.000	5.249E-03	1.097E-03	4.152E-03	.2089	.4040
40.000	7.979E-03	7.883E-04	7.191E-03	.0988	.2571

Table 30. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 70% Maritime Model

	NORMALIZED TO A NUMBER DENSITY OF	4000.	PARTICLES/CM3		
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	1.505E-01	1.248E-01	2.569E-02	.8293	.7738
.300	1.379E-01	1.344E-01	3.439E-03	.9751	.7288
.337	1.328E-01	1.305E-01	2.272E-03	.9829	.7243
.550	1.099E-01	1.085E-01	1.426E-03	.9870	.7214
.694	1.004E-01	9.926E-02	1.169E-03	.9884	.7211
1.060	8.474E-02	8.332E-02	1.413E-03	.9833	.7330
1.536	7.143E-02	7.012E-02	1.310E-03	.9817	.7445
2.000	6.033E-02	5.930E-02	1.026E-03	.9830	.7579
2.250	5.523E-02	5.423E-02	1.093E-03	.9818	.7649
2.500	4.950E-02	4.777E-02	1.730E-03	.9651	.7790
2.700	4.200E-02	3.587E-02	6.127E-03	.8541	.8182
3.000	5.561E-02	2.979E-02	2.582E-02	.5357	.7673
3.392	4.811E-02	4.376E-02	4.344E-03	.9097	.7171
3.750	4.185E-02	4.086E-02	9.926E-04	.9763	.7215
4.500	3.480E-02	3.254E-02	2.264E-03	.9350	.7235
5.000	3.020E-02	2.821E-02	1.995E-03	.9339	.7251
5.500	2.442E-02	2.259E-02	1.829E-03	.9251	.7397
6.000	2.311E-02	1.428E-02	8.821E-03	.6182	.7537
6.200	3.031E-02	2.146E-02	8.844E-03	.7082	.6934
6.500	2.315E-02	1.910E-02	4.044E-03	.8253	.7177
7.200	1.863E-02	1.518E-02	3.451E-03	.8148	.7193
7.900	1.562E-02	1.211E-02	3.503E-03	.7757	.7206
8.200	1.563E-02	1.149E-02	4.146E-03	.7351	.7151
8.700	1.864E-02	1.366E-02	4.980E-03	.7328	.6732
9.000	1.878E-02	1.379E-02	4.992E-03	.7342	.6620
9.200	1.762E-02	1.244E-02	5.182E-03	.7058	.6696
10.000	1.282E-02	9.079E-03	3.740E-03	.7082	.6921
10.591	1.073E-02	6.758E-03	3.972E-03	.6298	.6895
11.000	1.013E-02	5.371E-03	4.755E-03	.5304	.6898
11.500	1.030E-02	4.342E-03	5.960E-03	.4215	.6819
12.500	1.158E-02	2.982E-03	8.596E-03	.2575	.6556
14.800	1.382E-02	3.123E-03	1.069E-02	.2261	.5925
15.000	1.429E-02	3.234E-03	1.105E-02	.2264	.5869
16.400	1.498E-02	3.718E-03	1.126E-02	.2482	.5511
17.200	1.571E-02	4.476E-03	1.123E-02	.2849	.5284
18.500	1.485E-02	4.350E-03	1.050E-02	.2930	.5124
21.300	1.261E-02	3.555E-03	9.056E-03	.2819	.4912
25.000	1.062E-02	2.747E-03	7.871E-03	.2587	.4648
30.000	9.115E-03	1.961E-03	7.154E-03	.2152	.4302
40.000	1.138E-02	1.263E-03	1.011E-02	.1110	.3124

Table 31. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 80% Maritime Model

NORMALIZED TO A NUMBER DENSITY OF 4000. PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	2.683E-01	2.397E-01	2.859E-02	.8935	.7954
.300	2.516E-01	2.482E-01	3.415E-03	.9864	.7782
.337	2.455E-01	2.432E-01	2.228E-03	.99[illegible]9	.7752
.550	2.195E-01	2.181E-01	1.410E-03	.9936	.7717
.694	2.080E-01	2.068E-01	1.170E-03	.9944	.7721
1.060	1.921E-01	1.907E-01	1.452E-03	.9924	.7777
1.536	1.765E-01	1.749E-01	1.579E-03	.9911	.7872
2.000	1.601E-01	1.571E-01	2.927E-03	.9817	.8013
2.250	1.505E-01	1.489E-01	1.604E-03	.9893	.8089
2.500	1.364E-01	1.325E-01	3.972E-03	.9709	.83[illegible]1
2.700	1.097E-01	8.806E-02	2.159E-02	.8031	.8844
3.000	1.491E-01	6.720E-02	8.192E-02	.45[illegible]6	.8332
3.392	1.459E-01	1.246E-01	2.129E-02	.8541	.7557
3.750	1.300E-01	1.257E-01	4.316E-03	.9668	.7597
4.500	1.087E-01	9.752E-02	1.123E-02	.8968	.7823
5.000	9.804E-02	8.951E-02	9.534E-03	.9028	.7822
5.500	8.315E-02	7.502E-02	8.133E-03	.9022	.7944
6.000	7.885E-02	4.054E-02	3.83[illegible]E-02	.5142	.8157
6.200	9.510E-02	5.904E-02	3.614E-02	.62[illegible]	.7712
6.500	8.[illegible]4E-02	6.196E-02	1.928E-02	.7627	.7738
7.200	6.768E-02	5.259E-02	1.510E-02	.7770	.7784
7.900	5.801E-02	4.356E-02	1.445E-02	.75[illegible]9	.78[illegible]7
8.200	5.537E-02	4.046E-02	1.491E-02	.[illegible]308	.7800
8.700	5.466E-02	3.875E-02	1.591E-02	.7089	.7682
9.000	5.262E-02	3.653E-02	1.609E-02	.6943	.7659
9.200	4.996E-02	3.361E-02	1.635E-02	.6727	.7692
10.000	3.907E-02	2.365E-02	1.541E-02	.6054	.7780
10.591	3.362E-02	1.615E-02	1.747E-02	.48[illegible]3	.7628
11.000	3.374E-02	1.201E-02	2.173E-02	.3559	.7776
11.500	3.685E-02	9.460E-03	2.739E-02	.2567	.7621
12.500	4.907E-02	9.854E-03	3.922E-02	.2008	.7115
14.800	6.222E-02	1.389E-02	4.832E-02	.2233	.6342
15.000	6.294E-02	1.416E-02	4.878E-02	.2250	.6294
16.400	6.383E-02	1.543E-02	4.839E-02	.2418	.5999
17.200	6.373E-02	1.635E-02	4.739E-02	.2565	.5854
18.500	6.104E-02	1.640E-02	4.464E-02	.2687	.5700
21.300	5.237E-02	1.445E-02	3.792E-02	.2759	.5512
25.000	4.436E-02	1.214E-02	3.221E-02	.2737	.5265
30.000	3.606E-02	9.347E-03	2.671E-02	.2592	.4996
40.000	3.279E-02	5.519E-03	2.727E-02	.1683	.4236

Table 32. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 90% Maritime Model

	NORMALIZED TO A NUMBER DENSITY OF	4000.	PARTICLES/CM3		
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.280	3.844E-01	3.525E-01	3.192E-02	.9170	.8007
.300	3.619E-01	3.585E-01	3.362E-03	.9907	.7923
.337	3.526E-01	3.504E-01	2.216E-03	.9937	.7917
.550	3.146E-01	3.132E-01	1.408E-03	.9955	.7865
.694	2.988E-01	2.976E-01	1.177E-03	.9961	.7843
1.060	2.769E-01	2.754E-01	1.512E-03	.9946	.7947
1.536	2.579E-01	2.560E-01	1.844E-03	.9928	.7934
2.000	2.390E-01	2.342E-01	4.786E-03	.9799	.8269
2.250	2.272E-01	2.250E-01	2.226E-03	.9902	.8147
2.500	2.084E-01	2.022E-01	6.156E-03	.9705	.8783
2.700	1.689E-01	1.334E-01	3.547E-02	.7900	.8966
3.000	2.259E-01	9.994E-02	1.260E-01	.4423	.8468
3.392	2.240E-01	1.877E-01	3.630E-02	.8380	.7644
3.750	2.033E-01	1.958E-01	7.512E-03	.9630	.7671
4.500	1.731E-01	1.535E-01	1.958E-02	.8869	.7949
5.000	1.563E-01	1.417E-01	1.468E-02	.9068	.7944
5.500	1.369E-01	1.227E-01	1.418E-02	.8965	.8074
6.000	1.285E-01	6.509E-02	6.336E-02	.5067	.8335
6.200	[illegible]524E-01	9.269E-02	5.975E-02	.6080	.7960
6.500	[illegible]41E-01	1.010E-01	3.319E-02	.7526	.7897
7.200	[illegible]38E-01	8.779E-02	2.597E-02	.7717	.7946
7.900	[illegible]866E-02	7.391E-02	2.475E-02	.7491	.7978
8.200	9.376E-02	6.870E-02	2.506E-02	.7328	.7932
8.700	8.968E-02	6.348E-02	2.619E-02	.7079	.7920
9.000	8.564E-02	5.914E-02	2.650E-02	.6905	.7916
9.200	8.162E-02	5.482E-02	2.681E-02	.6715	.7044
10.000	6.498E-02	3.875E-02	2.623E-02	.5963	.8034
10.591	5.603E-02	2.623E-02	2.980E-02	.4682	.8088
11.000	5.636E-02	1.945E-02	3.691E-02	.3452	.8039
11.500	6.168E-02	1.557E-02	4.611E-02	.2524	.7583
12.500	8.262E-02	1.754E-02	6.509E-02	.2122	.7764
14.000	1.049E-01	2.503E-02	7.987E-02	.2386	.6589
15.000	1.059E-01	2.546E-02	8.044E-02	.2404	.6541
16.400	1.074E-01	2.746E-02	7.993E-02	.2557	.6246
17.200	1.069E-01	2.858E-02	7.835E-02	.2673	.6123
18.500	1.031E-01	2.881E-02	7.425E-02	.2796	.5966
21.300	8.952E-02	2.584E-02	6.368E-02	.2887	.5790
25.000	7.670E-02	2.220E-02	5.450E-02	.2895	.5533
30.000	6.260E-02	1.752E-02	4.508E-02	.2799	.5277
40.000	5.386E-02	1.047E-02	4.339E-02	.1944	.4600

Table 33. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 95% Maritime Model

NORMALIZED TO A NUMBER DENSITY OF 4000. PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	5.174E-01	4.840E-01	3.341E-02	.9354	.8079
.300	4.920E-01	4.887E-01	3.342E-03	.9932	.8035
.337	4.818E-01	4.796E-01	2.196E-03	.9954	.8034
.550	4.373E-01	4.359E-01	1.414E-03	.9968	.7986
.694	4.201E-01	4.189E-01	1.184E-03	.9972	.7955
1.060	3.966E-01	3.951E-01	1.539E-03	.9961	.7927
1.536	3.787E-01	3.764E-01	2.271E-03	.9940	.7994
2.000	3.602E-01	3.520E-01	8.152E-03	.9774	.8117
2.250	3.471E-01	3.438E-01	3.331E-03	.9904	.8193
2.500	3.239E-01	3.138E-01	1.014E-02	.9687	.8444
2.700	2.677E-01	2.087E-01	5.901E-02	.7796	.9068
3.000	3.399E-01	1.520E-01	1.879E-01	.4471	.8625
3.392	3.466E-01	2.849E-01	6.170E-02	.8220	.7738
3.750	3.216E-01	3.084E-01	1.329E-02	.9587	.7736
4.500	2.806E-01	2.463E-01	3.430E-02	.8777	.8056
5.000	2.606E-01	2.313E-01	2.931E-02	.8875	.8057
5.500	2.302E-01	2.052E-01	2.495E-02	.8916	.8186
6.000	2.119E-01	1.080E-01	1.039E-01	.5096	[illegible]
6.200	2.486E-01	1.500E-01	9.866E-02	.6032	.8393
6.500	2.255E-01	1.683E-01	5.722E-02	.7463	.8644
7.200	1.952E-01	1.502E-01	4.506E-02	.7692	.8094
7.900	1.717E-01	1.288E-01	4.291E-02	.7501	.8176
8.200	1.632E-01	1.202E-01	4.298E-02	.7366	.8148
8.700	1.532E-01	1.091E-01	4.408E-02	.7122	.8128
9.000	1.456E-01	1.011E-01	4.447E-02	.6945	.8138
9.200	1.393E-01	9.440E-02	4.496E-02	.6779	.8165
10.000	1.126E-01	6.754E-02	4.507E-02	.5998	.8262
10.591	9.682E-02	4.580E-02	5.102E-02	.4731	.8328
11.000	9.658E-02	3.401E-02	6.256E-02	.3522	.8286
11.500	1.047E-01	2.758E-02	7.707E-02	.2635	.8141
12.500	1.387E-01	3.226E-02	1.065E-01	.2326	.7632
14.800	1.757E-01	4.584E-02	1.299E-01	.2609	.6669
15.000	1.772E-01	4.656E-02	1.307E-01	.2627	.6822
16.400	1.804E-01	4.992E-02	1.305E-01	.2767	.6545
17.200	1.798E-01	5.147E-02	1.283E-01	.2862	.6415
18.500	1.747E-01	5.212E-02	1.226E-01	.2983	.6258
21.300	1.543E-01	4.758E-02	1.067E-01	.3083	.6071
25.000	1.343E-01	4.178E-02	9.254E-02	.3113	.5823
30.000	1.110E-01	3.386E-02	7.713E-02	.3051	.5573
40.000	9.252E-02	2.074E-02	7.178E-02	.2242	.4958

Table 34. Attenuation Coefficienta, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 98% Maritime Model

NORMALIZED TO A NUMBER DENSITY OF 4000. PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	7.895E-01	7.544E-01	3.507E-02	.9556	.8146
.300	7.614E-01	7.581E-01	3.349E-03	.9956	.8182
.337	7.516E-01	7.494E-01	2.191E-03	.9971	.8167
.550	6.998E-01	6.984E-01	1.420E-03	.9980	.8103
.694	6.783E-01	6.771E-01	1.198E-03	.9982	.8082
1.060	6.535E-01	6.518E-01	1.640E-03	.9975	.8011
1.536	6.399E-01	6.364E-01	3.481E-03	.9946	.8051
2.000	6.260E-01	6.088E-01	1.721E-02	.9725	.8167
2.250	6.137E-01	6.073E-01	6.358E-03	.9896	.8233
2.500	5.870E-01	5.660E-01	2.102E-02	.9642	.8495
2.700	5.038E-01	3.851E-01	1.187E-01	.7644	.9167
3.000	5.921E-01	2.709E-01	3.212E-01	.4575	.8816
3.392	6.202E-01	4.949E-01	1.253E-01	.7980	.7862
3.750	5.928E-01	5.638E-01	2.899E-02	.9511	.7802
4.500	5.363E-01	4.632E-01	7.311E-02	.8637	.8168
5.000	5.085E-01	4.454E-01	6.306E-02	.8760	.8177
5.500	4.621E-01	4.080E-01	5.413E-02	.8831	.9303
6.000	4.169E-01	2.155E-01	2.014E-01	.5168	.8712
6.200	4.817E-01	2.883E-01	1.934E-01	.5985	.8369
6.500	4.528E-01	3.338E-01	1.190E-01	.7372	.8213
7.200	4.035E-01	3.084E-01	9.514E-02	.7642	.8265
7.900	3.623E-01	2.715E-01	9.079E-02	.7494	.8317
8.200	3.459E-01	2.555E-01	9.033E-02	.7388	.8378
8.700	3.224E-01	2.312E-01	9.124E-02	.7170	.8355
9.000	3.064E-01	2.146E-01	9.176E-02	.7005	.8379
9.200	2.945E-01	2.022E-01	9.233E-02	.6865	.8405
10.000	2.428E-01	1.483E-01	9.449E-02	.6119	.8519
10.591	2.079E-01	1.020E-01	1.059E-01	.4908	.8634
11.000	2.037E-01	7.619E-02	1.275E-01	.3740	.8582
11.500	2.160E-01	6.240E-02	1.536E-01	.2888	.8459
12.500	2.787E-01	7.367E-02	2.051E-01	.2643	.7988
14.800	3.501E-01	1.027E-01	2.474E-01	.2933	.7259
15.000	3.529E-01	1.041E-01	2.488E-01	.2951	.7215
16.400	3.614E-01	1.111E-01	2.502E-01	.3075	.6945
17.200	3.614E-01	1.140E-01	2.475E-01	.3154	.6921
18.500	3.552E-01	1.160E-01	2.391E-01	.3267	.6662
21.300	3.215E-01	1.084E-01	2.131E-01	.3371	.6472
25.000	2.866E-01	9.784E-02	1.888E-01	.3414	.6223
30.000	2.425E-01	8.218E-02	1.603E-01	.3389	.5976
40.000	1.993E-01	5.270E-02	1.466E-01	.2644	.5425

Table 35. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 99% Maritime Model

NORMALIZED TO A NUMBER DENSITY OF 4000. PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	1.129E+00	1.093E+00	3.632E-02	.9678	.8203
.300	1.103E+00	1.100E+00	3.357E-03	.9970	.8270
.337	1.093E+00	1.091E+00	2.205E-03	.9980	.8260
.550	1.035E+00	1.033E+00	1.472E-03	.9986	.8196
.694	1.009E+00	1.008E+00	1.210E-03	.9988	.8176
1.060	9.810E-01	9.792E-01	1.784E-03	.9982	.8096
1.536	9.749E-01	9.694E-01	5.497E-03	.9944	.8096
2.000	9.694E-01	9.375E-01	3.190E-02	.9671	.8202
2.250	9.611E-01	9.497E-01	1.137E-02	.9882	.8255
2.500	9.356E-01	8.970E-01	3.869E-02	.9587	.8520
2.700	8.306E-01	6.225E-01	2.080E-01	.7495	.9228
3.000	9.234E-01	4.307E-01	4.927E-01	.4664	.8953
3.392	9.776E-01	7.586E-01	2.190E-01	.7760	.7965
3.750	9.536E-01	8.994E-01	5.420E-02	.9432	.7847
4.500	8.879E-01	7.546E-01	1.334E-01	.8498	.8242
5.000	8.548E-01	7.387E-01	1.161E-01	.8642	.8244
5.500	7.942E-01	6.940E-01	1.002E-01	.8738	.8376
6.000	7.104E-01	3.708E-01	3.395E-01	.5223	.8857
6.200	8.094E-01	4.806E-01	3.289E-01	.5937	.8463
6.500	7.789E-01	5.666E-01	2.123E-01	.7274	.8332
7.200	7.105E-01	5.381E-01	1.724E-01	.7573	.8379
7.900	6.491E-01	4.840E-01	1.651E-01	.7457	.8441
8.200	6.233E-01	4.594E-01	1.639E-01	.7370	.8467
8.700	5.831E-01	4.185E-01	1.646E-01	.7177	.8502
9.000	5.560E-01	3.908E-01	1.652E-01	.7028	.8534
9.200	5.367E-01	3.707E-01	1.661E-01	.6906	.8562
10.000	4.497E-01	2.789E-01	1.708E-01	.6201	.6688
10.591	3.850E-01	1.954E-01	1.896E-01	.5075	.8789
11.000	3.715E-01	1.468E-01	2.247E-01	.3953	.8785
11.500	3.862E-01	1.208E-01	2.654E-01	.3127	.8683
12.500	4.849E-01	1.411E-01	3.438E-01	.2909	.8252
14.000	6.026E-01	1.924E-01	4.102E-01	.3193	.7562
15.000	6.074E-01	1.950E-01	4.124E-01	.3210	.7519
16.400	6.246E-01	2.075E-01	4.170E-01	.3323	.7261
17.200	6.267E-01	2.125E-01	4.142E-01	.3391	.7141
18.500	6.209E-01	2.170E-01	4.039E-01	.3495	.6980
21.300	5.733E-01	2.062E-01	3.671E-01	.3597	.6789
25.000	5.213E-01	1.901E-01	3.312E-01	.3646	.6540
30.000	4.510E-01	1.642E-01	2.868E-01	.3640	.6294
40.000	3.720E-01	1.097E-01	2.623E-01	.2949	.5783

Table 36. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 0% Tropospheric Model

	NORMALIZED TO A NUMBER	DENSITY OF 5000.		PARTICLES/CM3	
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	9.775E-02	6.697E-02	3.079E-02	.6850	.7510
.300	8.075E-02	7.638E-02	4.378E-03	.9458	.6710
.337	7.381E-02	7.091E-02	2.901E-03	.9607	.6638
.550	4.419E-02	4.238E-02	1.811E-03	.9590	.6345
.694	3.200E-02	3.052E-02	1.482E-03	.9537	.6152
1.060	1.558E-02	1.398E-02	1.604E-03	.8971	.5736
1.536	6.732E-03	5.491E-03	1.241E-03	.8157	.5280
2.000	2.282E-03	1.896E-03	[illegible]	.83[illegible]6	[illegible]
2.250	1.707E-03	1.[illegible]01E-03	4.[illegible]65E-04	.7613	.47[illegible]
2.500	1.323E-03	9.122E-04	4.112E-04	.6893	.4467
2.700	2.064E-03	6.437E-04	1.420E-03	.3119	.4204
3.000	1.089E-03	5.195E-04	5.691E-04	.4772	.4028
3.392	6.786E-04	4.514E-04	2.272E-04	.6652	.3777
3.750	5.076E-04	3.680E-04	1.396E-04	.7250	.3563
4.500	4.565E-04	2.094E-04	2.471E-04	.4588	.3150
5.000	3.618E-04	1.425E-04	2.193E-04	.3938	.2919
5.500	3.810E-04	9.575E-05	2.852E-04	.2513	.2695
6.000	4.387E-04	5.661E-05	3.821E-04	.1290	.2465
6.200	4.666E-04	5.399E-05	4.127E-04	.1157	.2452
6.500	5.040E-04	5.078E-05	4.532E-04	.1007	.2313
7.200	7.718E-04	4.344E-05	7.284E-04	.0563	.2101
7.900	6.609E-04	7.467E-06	6.534E-04	.0113	.1760
8.200	1.069E-03	1.821E-06	1.067E-03	.0017	.1532
8.700	1.398E-03	1.239E-04	1.275E-03	.0886	.2091
9.000	1.495E-03	1.376E-04	1.358E-03	.0920	.2079
9.200	1.877E-03	9.636E-05	1.780E-03	.0513	.1843
10.000	7.082E-04	4.703E-05	6.612E-04	.0664	.1811
10.591	5.360E-04	3.208E-05	5.040E-04	.0599	.1687
11.000	4.132E-04	2.620E-05	3.870E-04	.0634	.1626
11.500	3.809E-04	1.985E-05	3.611E-04	.0521	.1526
12.500	3.648E-04	1.232E-05	3.525E-04	.0338	.1356
14.800	5.044E-04	4.623E-06	4.997E-04	.0092	.1030
15.000	8.502E-04	4.443E-06	8.458E-04	.0052	.0962
16.400	5.445E-04	6.121E-06	5.384E-04	.0112	.1024
17.200	5.965E-04	8.113E-06	5.884E-04	.0136	.1086
18.500	4.910E-04	4.610E-06	4.864E-04	.0094	.0928
21.300	3.734E-04	3.744E-06	5.697E-04	.0065	.0836
25.000	5.600E-04	1.836E-06	5.582E-04	.0033	.0643
30.000	6.265E-04	8.150E-07	6.258E-04	.0013	.0451
40.000	6.571E-04	3.576E-07	6.567E-04	.0005	.0290

Table 37. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 50% Tropospheric Model

	NORMALIZED TO A NUMBER DENSITY OF	5000.		PARTICLES/CM3	
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	1.014E-01	7.021E-02	3.116E-02	.6926	.7536
.300	8.357E-02	7.923E-02	4.338E-03	.9481	.6765
.337	7.643E-02	7.353E-02	2.903E-03	.9620	.6685
.550	4.580E-02	4.399E-02	1.805E-03	.9606	.6404
.694	3.319E-02	3.171E-02	1.481E-03	.9554	.6207
1.060	1.618E-02	1.458E-02	1.600E-03	.9006	.5787
1.536	7.008E-03	5.761E-03	1.247E-03	.8220	.5326
2.000	2.412E-03	2.021E-03	3.908E-04	.8379	.4991
2.250	1.796E-03	1.387E-03	4.089E-04	.7723	.4743
2.500	1.384E-03	9.679E-04	4.162E-04	.6993	.4511
2.700	2.131E-03	6.708E-04	1.461E-03	.3147	.4248
3.000	1.566E-03	5.584E-04	1.007E-03	.3566	.4032
3.392	7.536E-04	4.975E-04	2.561E-04	.6601	.3815
3.750	5.435E-04	3.992E-04	1.443E-04	.7345	.3602
4.500	4.868E-04	2.254E-04	2.614E-04	.4629	.3186
5.000	3.847E-04	1.536E-04	2.312E-04	.3991	.2954
5.500	3.986E-04	1.029E-04	2.957E-04	.2582	.2730
6.000	5.254E-04	6.074E-05	4.646E-04	.1156	.2490
6.200	5.365E-04	5.953E-05	4.770E-04	.1110	.2432
6.500	5.363E-04	5.543E-05	4.808E-04	.1034	.2347
7.200	7.970E-04	4.673E-05	7.503E-04	.0585	.2133
7.900	6.811E-04	8.646E-06	6.725E-04	.0127	.1798
8.200	1.087E-03	2.149E-06	1.085E-03	.0020	.1574
8.700	1.459E-03	1.289E-04	1.331E-03	.0883	.2101
9.000	1.570E-03	1.435E-04	1.427E-03	.0914	.2089
9.200	1.955E-03	1.002E-04	1.855E-03	.0513	.1858
10.000	7.424E-04	4.871E-05	6.937E-04	.0656	.1818
10.591	5.702E-04	3.310E-05	5.371E-04	.0581	.1695
11.000	4.535E-04	2.694E-05	4.265E-04	.0594	.1629
11.500	4.339E-04	2.034E-05	4.136E-04	.0469	.1528
12.500	4.500E-04	1.265E-05	4.373E-04	.0281	.1354
14.800	6.170E-04	4.950E-06	6.120E-04	.0080	.1034
15.000	9.658E-04	4.814E-06	9.610E-04	.0050	.0969
16.400	6.415E-04	6.525E-06	6.350E-04	.0102	.1024
17.200	6.814E-04	8.612E-06	6.728E-04	.0126	.1080
18.500	5.708E-04	4.951E-06	5.658E-04	.0087	.0930
21.300	6.341E-04	4.017E-06	6.301E-04	.0063	.0837
25.000	6.098E-04	1.984E-06	6.079E-04	.0033	.0649
30.000	6.671E-04	8.859E-07	6.662E-04	.0013	.0461
40.000	6.958E-04	3.865E-07	6.955E-04	.0006	.0290

Table 38. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 70% Tropospheric Model

NORMALIZED TO A NUMBER DENSITY OF 5000. PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	1.092E-01	7.710E-02	3.206E-02	.7066	.7571
.300	8.989E-02	8.555E-02	4.336E-03	.9518	.6893
.337	8.214E-02	7.927E-02	2.868E-03	.9651	.6790
.550	4.932E-02	4.752E-02	1.800E-03	.9635	.6510
.694	3.577E-02	3.429E-02	1.476E-03	.9587	.6315
1.060	1.750E-02	1.588E-02	1.617E-03	.9076	.5887
1.536	7.618E-03	6.358E-03	1.260E-03	.8346	.5418
2.000	2.701E-03	2.301E-03	4.003E-04	.8518	.5075
2.250	1.995E-03	1.581E-03	4.141E-04	.7925	.4829
2.500	1.520E-03	1.093E-03	4.270E-04	.7190	.4598
2.700	2.279E-03	7.311E-04	1.548E-03	.3208	.4338
3.000	2.599E-03	6.515E-04	1.947E-03	.2507	.4043
3.392	9.218E-04	6.028E-04	3.190E-04	.6539	.3890
3.750	6.247E-04	4.700E-04	1.547E-04	.7524	.3680
4.500	5.541E-04	2.614E-04	2.927E-04	.4717	.3259
5.000	4.357E-04	1.786E-04	2.571E-04	.4100	.3026
5.500	4.375E-04	1.192E-04	3.183E-04	.2724	.2800
6.000	7.143E-04	7.016E-05	6.441E-04	.0982	.2541
6.200	6.886E-04	7.230E-05	6.164E-04	.1050	.2494
6.500	6.070E-04	6.608E-05	5.410E-04	.1089	.2414
7.200	8.521E-04	5.422E-05	7.979E-04	.0636	.2196
7.900	7.260E-04	1.147E-05	7.146E-04	.0158	.1873
8.200	1.126E-03	3.116E-06	1.123E-03	.0028	.1657
8.700	1.584E-03	1.395E-04	1.445E-03	.0881	.2123
9.000	1.724E-03	1.557E-04	1.569E-03	.0903	.2110
9.200	2.113E-03	1.083E-04	2.004E-03	.0512	.1890
10.000	8.148E-04	5.230E-05	7.625E-04	.0642	.1836
10.591	6.439E-04	3.527E-05	6.087E-04	.0548	.1709
11.000	5.422E-04	2.851E-05	5.137E-04	.0526	.1640
11.500	5.518E-04	2.140E-05	5.305E-04	.0388	.1534
12.500	6.406E-04	1.339E-05	6.272E-04	.0209	.1354
14.000	8.644E-04	5.735E-06	8.587E-04	.0066	.1044
15.000	1.219E-03	5.692E-06	1.213E-03	.0047	.0984
16.400	8.570E-04	7.465E-06	8.495E-04	.0087	.1026
17.200	8.715E-04	9.745E-06	8.618E-04	.0112	.1073
18.500	7.474E-04	5.741E-06	7.417E-04	.0077	.0935
21.300	7.682E-04	4.637E-06	7.636E-04	.0060	.0842
25.000	7.192E-04	2.321E-06	7.169E-04	.0032	.0661
30.000	7.552E-04	1.048E-06	7.542E-04	.0014	.0477
40.000	7.797E-04	4.516E-07	7.792E-04	.0006	[illegible]

Table 39. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 80% Tropospheric Model

	NORMALIZED TO A NUMBER DENSITY OF 5000. PARTICLES/CM3				
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	1.482E-01	1.125E-01	3.572E-02	.7590	.7667
.300	1.214E-01	1.171E-01	4.307E-03	.9645	.7176
.337	1.112E-01	1.084E-01	2.812E-03	.9747	.7128
.550	6.764E-02	6.586E-02	1.781E-03	.9737	.6879
.694	4.958E-02	4.810E-02	1.476E-03	.9702	.6690
1.060	2.465E-02	2.300E-02	1.652E-03	.9330	.6255
1.536	1.101E-02	9.699E-03	1.309E-03	.8811	.5769
2.000	4.375E-03	3.928E-03	4.469E-04	.8979	.5403
2.250	3.152E-03	2.715E-03	4.370E-04	.8613	.5167
2.500	2.300E-03	1.820E-03	4.802E-04	.7913	.4947
2.700	3.067E-03	1.073E-03	1.994E-03	.3498	.4703
3.000	8.044E-03	1.272E-03	6.772E-03	.1581	.4143
3.392	1.917E-03	1.261E-03	6.552E-04	.6582	.4190
3.750	1.114E-03	9.048E-04	2.094E-04	.8121	.3993
4.500	9.387E-04	4.804E-04	4.583E-04	.5118	.3563
5.000	7.260E-04	3.324E-04	3.936E-04	.4578	.3325
5.500	6.554E-04	2.187E-04	4.366E-04	.3338	.3095
6.000	1.725E-03	1.287E-04	1.596E-03	.0746	.2767
6.200	1.505E-03	1.547E-04	1.350E-03	.1028	.2751
6.500	9.916E-04	1.337E-04	8.579E-04	.1348	.2693
7.200	1.144E-03	1.005E-04	1.043E-03	.0879	.2464
7.900	9.700E-04	3.183E-05	9.381E-04	.0329	.2175
8.200	1.347E-03	1.346E-05	1.333E-03	.0100	.1992
8.700	2.117E-03	1.904E-04	1.926E-03	.0899	.2247
9.000	2.378E-03	2.114E-04	2.166E-03	.0889	.2215
9.200	2.756E-03	1.467E-04	2.609E-03	.0532	.2042
10.000	1.165E-03	7.043E-05	1.095E-03	.0605	.1952
10.591	1.025E-03	4.619E-05	9.784E-04	.0451	.1814
11.000	1.025E-03	3.638E-05	9.889E-04	.0355	.1726
11.500	1.210E-03	2.688E-05	1.183E-03	.0222	.1604
12.500	1.718E-03	1.814E-05	1.700E-03	.0106	.1398
14.800	2.211E-03	1.140E-05	2.200E-03	.0052	.1111
15.000	2.579E-03	1.180E-05	2.567E-03	.0046	.1065
16.400	2.055E-03	1.373E-05	2.041E-03	.0067	.1068
17.200	1.952E-03	1.677E-05	1.935E-03	.0086	.1086
18.500	1.726E-03	1.094E-05	1.715E-03	.0063	.0984
21.300	1.509E-03	8.502E-06	1.500E-03	.0056	.0888
25.000	1.310E-03	4.470E-06	1.305E-03	.0034	.0724
30.000	1.219E-03	2.097E-06	1.217E-03	.0017	.0549
40.000	1.212E-03	8.597E-07	1.211E-03	.00.7	.0358

Table 40. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 90% Tropospheric Model

NORMALIZED TO A NUMBER DENSITY OF 5000. PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	2.154E-01	1.755E-01	3.994E-02	.8146	.7708
.300	1.784E-01	1.741E-01	4.234E-03	.9763	.7452
.337	1.651E-01	1.623E-01	2.797E-03	.9831	.7417
.550	1.037E-01	1.019E-01	1.778E-03	.9829	.7222
.694	7.729E-02	7.580E-02	1.496E-03	.9808	.7049
1.060	3.965E-02	3.796E-02	1.698E-03	.9572	.6635
1.536	1.842E-02	1.705E-02	1.370E-03	.9256	.6158
2.000	8.248E-03	7.716E-03	5.323E-04	.9355	.5785
2.250	5.861E-03	5.387E-03	4.736E-04	.9192	.5566
2.500	4.112E-03	3.534E-03	5.777E-04	.8595	.5366
2.700	4.699E-03	1.850E-03	2.849E-03	.3937	.5152
3.000	1.884E-02	2.873E-03	1.596E-02	.1525	.4355
3.392	4.292E-03	2.954E-03	1.339E-03	.6883	.4547
3.750	2.326E-03	2.008E-03	3.184E-04	.8631	.4375
4.500	1.822E-03	1.034E-03	7.883E-04	.5673	.3947
5.000	1.390E-03	7.254E-04	6.649E-04	.5218	.3707
5.500	1.142E-03	4.735E-04	6.687E-04	.4146	.3476
6.000	3.762E-03	2.804E-04	3.482E-03	.0745	.3081
6.200	3.179E-03	3.785E-04	2.800E-03	.1191	.3087
6.500	1.800E-03	3.148E-04	1.486E-03	.1748	.3052
7.200	1.739E-03	2.211E-04	1.518E-03	.1271	.2816
7.900	1.478E-03	9.486E-05	1.383E-03	.0642	.2554
8.200	1.822E-03	5.513E-05	1.766E-03	.0303	.2481
8.700	2.895E-03	2.869E-04	2.608E-03	.0991	.2477
9.000	3.284E-03	3.079E-04	2.976E-03	.0938	.2419
9.200	3.622E-03	2.192E-04	3.403E-03	.0605	.2291
10.000	1.794E-03	1.075E-04	1.686E-03	.0599	.2167
10.591	1.755E-03	6.852E-05	1.687E-03	.0390	.2015
11.000	1.997E-03	5.266E-05	1.945E-03	.0264	.1905
11.500	2.559E-03	3.905E-05	2.520E-03	.0153	.1761
12.500	3.956E-03	3.153E-05	3.925E-03	.0080	.1520
14.800	4.936E-03	2.913E-05	4.907E-03	.0059	.1235
15.000	5.304E-03	3.027E-05	5.274E-03	.0057	.1200
16.400	4.524E-03	3.195E-05	4.492E-03	.0071	.1171
17.200	4.225E-03	3.570E-05	4.189E-03	.0084	.1167
18.500	3.740E-03	2.593E-05	3.714E-03	.0069	.1088
21.300	3.029E-03	1.897E-05	3.010E-03	.0063	.0988
25.000	2.498E-03	1.046E-05	2.488E-03	.0042	.0832
30.000	2.128E-03	5.085E-06	2.123E-03	.0024	.0659
40.000	2.040E-03	1.981E-06	2.038E-03	.0010	.0434

Table 41. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 95% Tropospheric Model

	NORMALIZED TO A NUMBER DENSITY OF	5000.		PARTICLES/CM3	
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	2.602E-01	2.184E-01	4.180E-02	.8393	.7709
.300	2.184E-01	2.142E-01	4.214E-03	.9807	.7557
.337	2.031E-01	2.003E-01	2.772E-03	.9863	.7531
.550	1.306E-01	1.288E-01	1.785E-03	.9863	.7359
.694	9.842E-02	9.693E-02	1.495E-03	.9848	.7199
1.060	5.153E-02	4.981E-02	1.723E-03	.9666	.6804
1.536	2.450E-02	2.309E-02	1.403E-03	.9427	.6340
2.000	1.155E-02	1.095E-02	5.946E-04	.9485	.5970
2.250	8.193E-03	7.695E-03	4.980E-04	.9392	.5762
2.500	5.669E-03	5.020E-03	6.493E-04	.8855	.5575
2.700	5.997E-03	2.510E-03	3.487E-03	.4185	.5381
3.000	2.701E-02	4.285E-03	2.272E-02	.1587	.4489
3.392	6.357E-03	4.491E-03	1.866E-03	.7065	.4726
3.750	3.411E-03	3.010E-03	4.017E-04	.8822	.4569
4.500	2.577E-03	1.537E-03	1.040E-03	.5965	.4148
5.000	1.958E-03	1.087E-03	8.711E-04	.5551	.3907
5.500	1.553E-03	7.087E-04	8.439E-04	.4565	.3679
6.000	5.325E-03	4.207E-04	4.904E-03	.0790	.3255
6.200	4.489E-03	5.911E-04	3.898E-03	.1317	.3266
6.500	2.448E-03	4.865E-04	1.961E-03	.1987	.3243
7.200	2.208E-03	3.341E-04	1.874E-03	.1513	.3005
7.900	1.880E-03	1.592E-04	1.720E-03	.0847	.2752
8.200	2.201E-03	1.019E-04	2.099E-03	.0463	.2611
8.700	3.401E-03	3.636E-04	3.038E-03	.1069	.2622
9.000	3.841E-03	3.807E-04	3.460E-03	.0991	.2554
9.200	4.155E-03	2.767E-04	3.878E-03	.0666	.2442
10.000	2.251E-03	1.381E-04	2.113E-03	.0614	.2302
10.591	2.299E-03	8.698E-05	2.212E-03	.0378	.2141
11.000	2.731E-03	6.629E-05	2.665E-03	.0243	.2020
11.500	3.584E-03	4.976E-05	3.534E-03	.0139	.1865
12.500	5.663E-03	4.478E-05	5.618E-03	.0079	.1606
14.800	7.003E-03	4.743E-05	6.956E-03	.0068	.1314
15.000	7.364E-03	4.906E-05	7.314E-03	.0067	.1282
16.400	6.412E-03	5.025E-05	6.362E-03	.0078	.1240
17.200	5.976E-03	5.408E-05	5.922E-03	.0090	.1228
18.500	5.279E-03	4.090E-05	5.239E-03	.0077	.1157
21.300	4.189E-03	2.919E-05	4.160E-03	.0070	.1054
25.000	3.399E-03	1.641E-05	3.383E-03	.0048	.0900
30.000	2.811E-03	8.097E-06	2.803E-03	.0029	.0725
40.000	2.656E-03	3.095E-06	2.653E-03	.0012	.0481

Table 42. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 98% Tropospheric Model

	NORMALIZED TO A NUMBER DENSITY OF 5000.			PARTICLES/CM3	
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	3.316E-01	2.877E-01	4.391E-02	.8676	.7703
.300	2.854E-01	2.812E-01	4.222E-03	.9852	.7659
.337	2.673E-01	2.645E-01	2.764E-03	.9897	.7643
.550	1.777E-01	1.760E-01	1.793E-03	.9899	.7507
.694	1.363E-01	1.348E-01	1.511E-03	.9889	.7365
1.060	7.352E-02	7.176E-02	1.756E-03	.9761	.7000
1.536	3.609E-02	3.464E-02	1.450E-03	.9598	.6561
2.000	1.802E-02	1.732E-02	7.043E-04	.96[illegible]9	.6202
2.250	1.282E-02	1.229E-02	5.389E-04	.9580	.6008
2.500	8.760E-03	7.992E-03	7.756E-04	.9115	.5841
2.700	8.439E-03	3.818E-03	4.622E-03	.4524	.5677
3.000	4.162E-02	7.095E-03	3.453E-02	.1705	.4681
3.392	1.048E-02	7.654E-03	2.829E-03	.7301	.4955
3.750	5.637E-03	5.085E-03	5.525E-04	.9020	.4819
4.500	4.081E-03	2.587E-03	1.493E-03	.634[illegible]	.4411
5.000	3.089E-03	1.847E-03	1.243E-03	.5978	.4172
5.500	2.363E-03	1.205E-03	1.158E-03	.51[illegible]	.3948
6.000	8.157E-03	7.162E-04	7.441E-03	.0878	.3494
6.200	6.912E-03	1.046E-03	5.866E-03	.1514	.3506
6.500	3.670E-03	8.555E-04	2.815E-03	.2331	.3497
7.200	3.086E-03	5.762E-04	2.510E-03	.1867	.3260
7.900	2.628E-03	3.043E-04	2.324E-03	.1158	.3015
8.200	2.910E-03	2.126E-04	2.697E-03	.0731	.2886
8.700	4.252E-03	5.124E-04	3.740E-03	.1205	.2834
9.000	4.741E-03	5.182E-04	4.223E-03	.1093	.2756
9.200	5.023E-03	3.882E-04	4.635E-03	.0773	.2659
10.000	3.056E-03	1.988E-04	2.857E-03	.0651	.2499
10.591	3.263E-03	1.236E-04	3.139E-03	.0379	.2327
11.000	4.039E-03	9.360E-05	3.946E-03	.0232	.2192
11.500	5.410E-03	7.195E-05	5.338E-03	.0133	.2022
12.500	8.710E-03	7.418E-05	8.635E-03	.0085	.1736
14.000	1.070E-02	8.911E-05	1.061E-02	.0083	.1431
15.000	1.104E-02	9.152E-05	1.095E-02	.0083	.1402
16.400	9.797E-03	9.143E-05	9.706E-03	.0093	.1345
17.200	9.125E-03	9.469E-05	9.030E-03	.0104	.1325
18.500	8.042E-03	7.474E-05	7.967E-03	.0093	.1260
21.300	6.271E-03	5.198E-05	6.219E-03	.0083	.1154
25.000	5.009E-03	2.987E-05	4.979E-03	.0060	.0998
30.000	4.025E-03	1.500E-05	4.010E-03	.0037	.0820
40.000	3.745E-03	5.631E-06	3.740E-03	.0015	.0551

Table 43. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 99% Tropospheric Model

	NORMALIZED TO A NUMBER DENSITY OF 5000. PARTICLES/CM3				
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	4.020E-01	3.574E-01	4.547E-02	.8871	.7696
.300	3.550E-01	3.508E-01	4.230E-03	.9881	.7719
.337	3.346E-01	3.319E-01	2.782E-03	.9917	.7710
.550	2.293E-01	2.275E-01	1.808E-03	.9921	.7606
.694	1.784E-01	1.769E-01	1.524E-03	.9915	.7478
1.060	9.891E-02	9.713E-02	1.785E-03	.9820	.7142
1.536	4.993E-02	4.843E-02	1.493E-03	.9701	.6727
2.000	2.597E-02	2.515E-02	8.262E-04	.9682	.6381
2.250	1.857E-02	1.799E-02	5.822E-04	.9686	.6201
2.500	1.263E-02	1.171E-02	9.164E-04	.9274	.6050
2.700	1.133E-02	5.444E-03	5.889E-03	.4804	.5912
3.000	5.799E-02	1.055E-02	4.744E-02	.1829	.4849
3.392	1.563E-02	1.170E-02	3.932E-03	.7484	.5137
3.750	8.485E-03	7.763E-03	7.241E-04	.9147	.5019
4.500	5.961E-03	3.953E-03	2.007E-03	.6632	.4625
5.000	4.506E-03	2.844E-03	1.663E-03	.6310	.4389
5.500	3.373E-03	1.861E-03	1.512E-03	.5517	.4169
6.000	1.138E-02	1.104E-03	1.028E-02	.0971	.3696
6.200	9.732E-03	1.653E-03	8.079E-03	.1698	.3707
6.500	5.126E-03	1.350E-03	3.776E-03	.2633	.3708
7.200	4.124E-03	9.004E-04	3.223E-03	.2183	.3473
7.900	3.580E-03	5.064E-04	3.002E-03	.1443	.3232
8.200	3.742E-03	3.719E-04	3.371E-03	.0994	.3112
8.700	5.182E-03	6.974E-04	4.495E-03	.1346	[illegible]
9.000	5.697E-03	6.856E-04	5.012E-03	.1203	.2938
9.200	5.951E-03	5.269E-04	5.425E-03	.0885	.2850
10.000	3.955E-03	2.757E-04	3.680E-03	.0697	.2675
10.591	4.340E-03	1.700E-04	4.170E-03	.0392	.2494
11.000	5.500E-03	1.284E-04	5.372E-03	.0234	.2347
11.500	7.448E-03	1.010E-04	7.347E-03	.0136	.2165
12.500	1.211E-02	1.147E-04	1.200E-02	.0095	.1857
14.800	1.482E-02	1.477E-04	1.468E-02	.0100	.1536
15.000	1.514E-02	1.510E-04	1.499E-02	.0100	.1509
16.400	1.359E-02	1.490E-04	1.344E-02	.0110	.1441
17.200	1.266E-02	1.508E-04	1.251E-02	.0119	.1416
18.500	1.114E-02	1.223E-04	1.102E-02	.0110	.1354
21.300	8.600E-03	8.383E-05	8.524E-03	.0097	.1245
25.000	6.812E-03	4.894E-05	6.764E-03	.0072	.1088
30.000	5.382E-03	2.491E-05	5.357E-03	.0046	.0905
40.000	4.957E-03	9.265E-06	4.948E-03	.0019	.0614

Table 44. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for the Advection Fog 1 Model

	NORMALIZED TO A NUMBER DENSITY OF	20.00	PARTICLES/CM3		
WAVELENGTH	EXTINCTION	SCATTERING	ABSORPTION	SINGLE	ASYMMETRY
(MICRON)	(KM-1)	(KM-1)	(KM-1)	SCAT. ALB.	PARAMETER
.200	2.831E+01	2.831E+01	3.544E-03	.9999	.8578
.300	2.849E+01	2.849E+01	3.385E-04	1.0000	.8726
.337	2.847E+01	2.847E+01	1.597E-04	1.0000	.8722
.550	2.874E+01	2.874E+01	2.399E-05	1.0000	.8717
.694	2.890E+01	2.890E+01	2.973E-04	1.0000	.8703
1.060	2.924E+01	2.921E+01	2.718E-02	.9991	.8652
1.536	2.965E+01	2.921E+01	4.353E-01	.9853	.8618
2.000	2.993E+01	2.681E+01	3.120E+00	.8957	.8798
2.250	3.009E+01	2.897E+01	1.118E+00	.9628	.8689
2.500	3.027E+01	2.645E+01	3.813E+00	.8740	.8918
2.700	3.043E+01	1.688E+01	1.354E+01	.5549	.9641
3.000	3.014E+01	1.586E+01	1.428E+01	.5263	.9502
3.392	3.070E+01	1.754E+01	1.316E+01	.5714	.9297
3.750	3.098E+01	2.583E+01	5.148E+00	[illegible]	.8544
4.500	3.140E+01	2.066E+01	1.074E+01	.6580	[illegible]
5.000	3.171E+01	2.177E+01	9.942E+00	.6865	.8885
5.500	3.209E+01	2.294E+01	9.157E+00	.7147	.8812
6.000	3.173E+01	1.588E+01	1.586E+01	.5003	.9604
6.200	3.200E+01	1.619E+01	1.581E+01	.5059	.9470
6.500	3.244E+01	1.808E+01	1.436E+01	.5573	.9193
7.200	3.304E+01	1.973E+01	1.332E+01	.5970	.9039
7.900	3.368E+01	2.048E+01	1.320E+01	.6080	.9039
8.200	3.399E+01	2.079E+01	1.319E+01	.6118	.9057
8.700	3.452E+01	2.128E+01	1.324E+01	.6164	.9110
9.000	3.485E+01	2.156E+01	1.329E+01	.6187	.9158
9.200	3.504E+01	2.171E+01	1.333E+01	.6196	.9194
10.000	3.525E+01	2.169E+01	1.356E+01	.6153	.9381
10.590	3.321E+01	1.916E+01	1.405E+01	.5769	.9537
11.000	3.037E+01	1.558E+01	1.479E+01	.5130	.9595
11.500	2.824E+01	1.299E+01	1.526E+01	.4598	.9587
12.500	2.906E+01	1.318E+01	1.588E+01	.4535	.9418
14.800	3.187E+01	1.501E+01	1.686E+01	.4711	.9181
15.000	3.203E+01	1.510E+01	1.692E+01	.4716	.9081
16.400	3.295E+01	1.560E+01	1.735E+01	.4736	.8957
17.200	3.340E+01	1.583E+01	1.757E+01	.4739	.8898
18.500	3.406E+01	1.615E+01	1.791E+01	.4742	.8812
21.300	3.494E+01	1.651E+01	1.843E+01	.4726	.8685
25.000	3.581E+01	1.695E+01	1.886E+01	.4734	.8491
30.000	3.645E+01	1.740E+01	1.935E+01	.4775	.8246
40.000	3.463E+01	1.555E+01	1.978E+01	.4490	.7815

Table 45. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for the Advection Fog 2 Model

	NORMALIZED TO A NUMBER DENSITY OF 20.00 PARTICLES/CM3				
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	1.816E+01	1.816E+01	1.839E-03	.9999	.8570
.300	1.830E+01	1.830E+01	1.786E-04	1.0000	.8715
.337	1.828E+01	1.828E+01	8.240E-05	1.0000	.8707
.550	1.849E+01	1.849E+01	1.262E-05	1.0000	.8691
.694	1.859E+01	1.859E+01	1.591E-04	1.0000	.8676
1.060	1.886E+01	1.884E+01	1.459E-02	.9992	.8604
1.536	1.916E+01	1.8[illegible]E+01	2.319E-01	.9879	.8553
2.000	1.937E+01	1.7[illegible]	1.600E+00	.91[illegible]	.8705
2.250	1.949E+01	[illegible]	5.946E-01	.9695	.8604
2.500	1.962E+01	1.756E+01	2.066E+00	.8947	.8[illegible]6
2.700	1.980E+01	1.146E+01	8.339E+00	.5788	.9543
3.000	1.950E+01	1.016E+01	9.340E+00	.5210	.9487
3.392	1.994E+01	1.179E+01	8.154E+00	.5911	.9148
3.750	2.017E+01	1.732E+01	2.857E+00	.8584	.8375
4.500	2.052E+01	1.419E+01	6.325E+00	.6917	.8794
5.000	2.078E+01	1.500E+01	5.778E+00	.7219	.8664
5.500	2.115E+01	1.591E+01	5.238E+00	.7523	.8616
6.000	2.078E+01	1.049E+01	1.029E+01	.5049	.9535
6.200	2.099E+01	1.070E+01	1.029E+01	.5096	.9259
6.500	2.141E+01	1.251E+01	8.904E+00	.5842	.8989
7.200	2.202E+01	1.400E+01	8.018E+00	.6359	.8864
7.900	2.262E+01	1.474E+01	7.876E+00	.6518	.8912
8.200	2.288E+01	1.503E+01	7.847E+00	.6570	.8951
8.700	2.325E+01	1.540E+01	7.849E+00	.6624	.9034
9.000	2.341E+01	1.554E+01	7.864E+00	.6640	.9095
9.200	2.346E+01	1.558E+01	7.884E+00	.6640	.9137
10.000	2.284E+01	1.481E+01	8.035E+00	.6482	.933[illegible]
10.590	2.054E+01	1.211E+01	8.433E+00	.5894	.9469
11.000	1.845E+01	9.377E+00	9.076E+00	.5082	.9515
11.500	1.718E+01	7.615E+00	9.561E+00	.44[illegible]	.9497
12.500	1.811E+01	7.874E+00	1.024E+01	.4348	.9313
14.800	2.036E+01	9.280E+00	1.108E+01	.4559	.8966
15.000	2.048E+01	9.352E+00	1.113E+01	.4567	.8943
16.400	2.119E+01	9.744E+00	1.144E+01	.4599	.8799
17.200	2.153E+01	9.927E+00	1.160E+01	.4612	.8729
18.500	2.201E+01	1.019E+01	1.182E+01	.4631	.8622
21.300	2.255E+01	1.048E+01	1.207E+01	.4648	.8455
25.000	2.297E+01	1.075E+01	1.222E+01	.4681	.8212
30.000	2.297E+01	1.088E+01	1.209E+01	.4735	.7912
40.000	2.089E+01	9.013E+00	1.188E+01	.4315	.7348

Table 46. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Radiation Fog 1 Model

NORMALIZED TO A NUMBER DENSITY OF 100.0 PARTICLES/CM3

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	1.617E+01	1.617E+01	6.339E-04	1.0000	.8460
.300	1.631E+01	1.631E+01	5.969E-05	1.0000	.8578
.337	1.637E+01	1.637E+01	2.784E-05	1.0000	.8591
.550	1.661E+01	1.661E+01	4.071E-06	1.0000	.8557
.694	1.683E+01	1.683E+01	5.194E-05	1.0000	.8476
1.060	1.730E+01	1.730E+01	5.470E-03	.9997	.8340
1.536	1.773E+01	1.765E+01	8.465E-02	.9952	.8177
2.000	1.810E+01	1.744E+01	6.688E-01	.9631	.8102
2.250	1.839E+01	1.817E+01	2.181E-01	.9881	[illegible]
2.500	1.909E+01	1.829E+01	8.006E-01	.9581	.8278
2.700	2.118E+01	1.623E+01	4.952E+00	.7662	.9334
3.000	1.815E+01	8.912E+00	9.237E+00	.4911	.9338
3.392	1.921E+01	1.381E+01	5.410E+00	.7185	.8008
3.750	2.027E+01	1.906E+01	1.206E+00	.9405	.7547
4.500	2.274E+01	1.960E+01	3.141E+00	.8619	.8273
5.000	2.387E+01	2.119E+01	2.681E+00	.8877	.8382
5.500	2.428E+01	2.202E+01	2.255E+00	.9071	.8626
6.000	1.916E+01	1.091E+01	8.254E+00	.5692	.9125
6.200	2.187E+01	1.366E+01	8.209E+00	.6247	.8773
6.500	2.326E+01	1.805E+01	5.218E+00	.7757	.8606
7.200	2.202E+01	1.791E+01	4.113E+00	.8136	.8657
7.900	1.982E+01	1.593E+01	3.888E+00	.8038	.8680
8.200	1.873E+01	1.489E+01	3.836E+00	.7952	.8682
8.700	1.682E+01	1.301E+01	3.807E+00	.7737	.8676
9.000	1.550E+01	1.178E+01	3.808E+00	.7556	.8671
9.200	1.476E+01	1.094E+01	3.822E+00	.7411	.8666
10.000	1.131E+01	7.324E+00	3.983E+00	.6477	.8641
10.590	9.065E+00	4.592E+00	4.473E+00	.5066	.8612
11.000	8.715E+00	3.329E+00	5.385E+00	.3820	.8562
11.500	9.154E+00	2.752E+00	6.402E+00	.3006	.8455
12.500	1.173E+01	3.529E+00	8.200E+00	.3009	.8142
14.800	1.503E+01	5.211E+00	9.818E+00	.3467	.7540
15.000	1.518E+01	5.298E+00	9.884E+00	.3490	.7495
16.400	1.593E+01	5.751E+00	1.018E+01	.3609	.7187
17.200	1.617E+01	5.935E+00	1.024E+01	.3670	.7024
18.500	1.633E+01	6.146E+00	1.018E+01	.3764	.6772
21.300	1.529E+01	5.795E+00	9.495E+00	.3790	.6286
25.000	1.377E+01	5.133E+00	8.634E+00	.3728	.5642
30.000	1.131E+01	3.982E+00	7.328E+00	.3521	.4835
40.000	8.476E+00	2.079E+00	6.397E+00	.2453	.3301

Table 47. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Radiation Fog 2 Model

	NORMALIZED TO A NUMBER DENSITY OF	200.0		PARTICLES/CM3	
WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	8.220E+00	8.220E+00	1.614E-04	1.0000	.6308
.300	8.344E+00	8.344E+00	1.720E-05	1.0000	.8459
.337	8.417E+00	8.417E+00	8.058E-06	1.0000	.8419
.550	8.672E+00	8.672E+00	1.175E-06	1.0000	.8286
.694	8.754E+00	8.754E+00	1.409E-05	1.0000	.8224
1.060	9.121E+00	9.120E+00	1.351E-03	.9999	.7883
1.536	9.758E+00	9.737E+00	2.125E-02	.9978	.7763
2.000	1.124E+01	1.106E+01	1.723E-01	.9847	.8133
2.250	1.207E+01	1.202E+01	5.371E-02	.9956	.6393
2.500	1.224E+01	1.204E+01	2.014E-01	.9835	.8767
2.700	9.081E+00	7.589E+00	1.492E+00	.8357	.9256
3.000	9.610E+00	4.586E+00	5.024E+00	.4772	.8982
3.392	1.243E+01	1.071E+01	1.718E+00	.8617	.7887
3.750	1.260E+01	1.230E+01	3.013E-01	.9761	.8082
4.500	1.029E+01	9.459E+00	8.357E-01	.9188	.8319
5.000	9.051E+00	8.357E+00	6.937E-01	.9234	.8243
5.500	7.142E+00	6.571E+00	5.711E-01	.9200	.8210
6.000	6.222E+00	3.222E+00	3.000E+00	.5179	.8282
6.200	8.014E+00	5.177E+00	2.836E+00	.6461	.8037
6.500	6.881E+00	5.404E+00	1.476E+00	.7854	.7904
7.200	5.226E+00	4.130E+00	1.096E+00	.7903	.7728
7.900	4.135E+00	3.110E+00	1.025E+00	.7522	.7528
8.200	3.744E+00	2.736E+00	1.008E+00	.7307	.7436
8.700	3.185E+00	2.187E+00	9.989E-01	.6864	.7274
9.000	2.884E+00	1.884E+00	1.001E+00	.6531	.7171
9.200	2.704E+00	1.698E+00	1.006E+00	.6280	.7100
10.000	2.093E+00	1.024E+00	1.069E+00	.4893	.6790
10.590	1.873E+00	6.188E-01	1.255E+00	.3303	.6520
11.000	2.082E+00	4.656E-01	1.616E+00	.2237	.6305
11.500	2.499E+00	4.128E-01	2.086E+00	.1652	.6020
12.500	3.701E+00	6.295E-01	3.071E+00	.1701	.5475
14.800	4.931E+00	1.039E+00	3.892E+00	.2106	.4577
15.000	4.966E+00	1.056E+00	3.911E+00	.2125	.4511
16.400	5.038E+00	1.117E+00	3.921E+00	.2216	.4084
17.200	4.957E+00	1.117E+00	3.840E+00	.2254	.3872
18.500	4.704E+00	1.081E+00	3.623E+00	.2298	.3566
21.300	3.814E+00	8.282E-01	2.986E+00	.2171	.2976
25.000	2.990E+00	5.766E-01	2.413E+00	.1929	.2340
30.000	2.160E+00	3.331E-01	1.827E+00	.1542	.1711
40.000	1.673E+00	1.237E-01	1.549E+00	.0740	.0956

4. THE USE OF THE AEROSOL MODELS

4.1 Boundary Layer Models

The aerosol models defined in this report are representative for various general types of environments. Yet, there is no clear answer to the simple question: Which model should be used for what location and weather situation? Some discussion on this point is necessary to give the user some guidance in choosing the optimum model for a given condition.

For the boundary layer of the atmosphere up to 1 - 2 km above the surface, the composition of the aerosol particles is primarily controlled by sources (natural and man-made) at the earth's surface. The aerosol content of the atmosphere at a given location, will therefore depend on the trajectory of the local air mass during the preceding several days, and the meteorological history of the air mass. The amount of mixing in the atmosphere is controlled by the temperature profile and the winds. Precipitation will tend to wash the aerosol out of the atmosphere, although it should be noted that "frontal showers" often mark the boundary between two different air masses with generally different histories and correspondingly different aerosol contents.

The "rural" and the "urban" model are intended to distinguish between aerosol types of natural and man-made origin over a land area. Clearly, the man-made aerosol will be predominantly found in urban-industrial areas. However, it is quite likely that after passage of a cold front, clear polar air also covers an urban area and that therefore the rural aerosol model, which is free of the component of industrial-carbonaceous aerosols, is more applicable. After a few days, as the clean air mass begins to accumulate local pollution however, the urban model will once again become more representative.

Conversely, very often the pollution plume from major urban-industrial areas may, under stagnant weather conditions, diffuse over portions of a continent (for example, Central Europe, Northeastern United States), including its rural sections.

There is also a distinct difference between the composition of aerosols over the ocean and those over land areas due to the different surface-based sources. Aerosols in maritime environments have a very pronounced component of sea-salt particles from the sea water. Sea-salt particles are formed from sea spray from breaking waves. The larger particles fall out, but the smaller particles are transported up with the atmospheric mixing in the boundary layer. In coastal regions the relative proportions of particles of continental and oceanic origins will vary, depending on the strength and direction of the prevailing winds at time of observation.

While changes in visibility are often associated with changes in the relative humidity,[93] (as the relative humidity approaches 100 percent the visibility tends to

decrease), it is not possible to define a unique functional relationship between the meteorological range and relative humidity for the free atmosphere. However, for aerosols in a closed system, where aerosol changes can be controlled, such a functional relationship can be developed. Such an expression has been derived empirically by Kasten[31] and has been used by Hänel[27, 28]

$$\frac{V(f_1)}{V(f_2)} \approx \left(\frac{1-f_1}{1-f_2}\right)^{\nu} \tag{14}$$

where V is the meteorological range and f is the fractional relative humidity, with $0.7 \lesssim f_1, f_2 \lesssim 0.995$, and ν is a model dependent parameter. For the Rural and Tropospheric Models $\nu \simeq 0.42$, for the Urban Aerosol Model $\nu \simeq 0.57$ and for the Maritime Aerosol Model $\nu \simeq 0.58$.

Since the natural atmosphere is not a closed system and changes in the relative humidity do not necessarily take place in isolation from other changes, Eq. (14) should be used with caution. The measurements presented by Filippov and Mirumyants[94] clearly illustrate the difficulties in defining a simple unique expression relating visibility and relative humidity. Where the changes in the relative humidity are primarily due to changes in the air temperature, with a constant dew point, that is, solar heating during the day or radiational cooling at night, then Eq. (14) can be expected to be approximately valid for relative humidity greater than 70-80 percent.

4.2 Tropospheric Aerosol Model

The Tropospheric Aerosol Model has been developed primarily for application in the troposphere, above the boundary layer, where the aerosols are not as sensitive to local sources or largely controlled by the mixing of the first 1 to 2 km of the atmosphere. However, the Tropospheric Model may be applicable to near ground level for particularly clear and calm conditions (in pollution free areas with visibilities greater than 30 to 40 km), where there has been little turbulent mixing for a period of one to two days, permitting the larger particles to have settled out of the atmosphere without being replaced by dust blown into the air from the surface. (The sedimentation rate of a 10 μm radius aerosol particle is approximately 1 km per day.)[95]

4.3 Fog Models

The Fog Models described in Section 2.5 were presented in terms of the atmospheric conditions leading to the development of the fog, so this provides a good basis for deciding which fog model to use. In more general terms, for heavy

fogs the visibilities will be less than 200-250 m and the extinction will be virtually independent of wavelength. For these conditions Fog Model 1 should be used. For light to moderate fogs, the visibility will generally exceed 350 m and there will be a noticeable difference between the extinction for visible wavelengths and in the 8-12 μm window. For such cases Fog Model 4 should be used. For very light fog conditions where the visibility may be about 1 km, the 99 percent relative humidity aerosol models may represent the wavelength dependence of the atmospheric extinction as well as any of the fog models.

References

1. Elterman, L. (1964) Atmospheric Attenuation Model, 1964, in the Ultraviolet, Visible, and Infrared Regions for Altitudes to 50 km, AFCRL-64-740.

2. Elterman, L. (1968) UV, Visible, and IR Attenuation for Altitudes to 50 km, 1968, AFCRL-68-0153, AD 671933.

3. Elterman, L. (1970) Vertical Attenuation Model with Eight Surface Meteorological Ranges 2 to 13 kilometers, AFCRL-70-0200, AD 707488.

4. McClatchey, R.A., Fenn, R.W., Selby, J.E.A., Volz, F.E., and Garing, J.S. (1970) Optical Properties of the Atmosphere, AFCRL-70-0527, AD 715270.

5. McClatchey, R.A., Fenn, R.W., Selby, J.E.A., Volz, F.E., and Garing, J.S. (1972) Optical Properties of the Atmosphere (Third Edition), AFCRL-72-0497, AD 753075.

6. Ivlev, L.S. (1967) Aerosol model of the atmosphere, Prob. Fiz. Atmos. No. 7:125-160, Leningrad, translated by Foreign Science and Technology Ctr, Dept. of the Army, available from U.S. National Technical Information Service, AD 760393.

7. Ivlev, L.S. (1969) Atmospheric aerosol, pp 28-42 in Radiation Characteristics of the Atmosphere and the Earth's Surface, Ed. K. Ya Kondratev, Amerind Publishing Co., New Delhi, available from U.S. National Technical Information Service, No. TT-71-58003.

8. Shettle, E.P., and Fenn, R.W. (1976) Models of the atmospheric aerosols and their optical properties, in AGARD Conference Proceedings No. 183 Optical Propagation in the Atmosphere. Presented at the Electromagnetic Wave Propagation Panel Symposium, Lyngby, Denmark, 27-31 October 1975, AGARD-CP-183, available from U.S. National Technical Information Service, AD A028-615.

9. Toon, O.B., and Pollack, J.B. (1976) A global average model of atmospheric aerosols for radiative transfer calculations, J. Appl. Meteor., 15:225-246.

10. Fenn, R.W. (1964) Aerosol-Verteilungen und atmospharisches Streulicht, Beitr. Physik Atmos., 37:69-104.

11. Whitby, K. T., Husar, R. B., and Liu, B. Y. H. (1972) The aerosol size distribution of Los Angeles smog, J. Colloid Interface Sci. 39:177-204.

12. Whitby, K. T., Clark, W. E., Marple, V. A., Sverdrup, G. M., Sem, G. J., Willeke, K., Liu, B. Y. H., and Pui, D. Y. H. (1975) Characterization of California aerosols - I. Size distributions of Freeway aerosol, Atmos. Environ. 9:463-482.

13. Willeke, K., Whitby, K. T., Clark, W. E., and Marple, V. A. (1974) Size distributions of Denver aerosols - A comparison of two sites, Atmos. Environ. 8:609-633.

14. Twitty, J. T., Parent, R. J., Weinman, J. A., and Eloranta, E. W. (1976) Aerosol size distributions. Remote determination from airborne measurements of the solar aureole, Appl. Opt. 15:980-989.

15. Harris, F. S., Jr., and McCormick, M. P. (1972) Mie scattering by three polydispersions, J. Colloid. Sci. 39:536-545.

16. Davies, C. N. (1974) Size distribution of atmospheric particles, J. Aerosol Sci. 5:293-300.

17. Whitby, K. T., and Cantrell, B. (1975) Atmospheric aerosols - Characteristics and measurements, International Conf. on Environmental Sensing and Assessment, 2, Las Vegas, Nev., 14-19 September 1975.

18. Lundgren, Dale A. (1970) Atmospheric aerosol composition and concentrations as a function of particle size and of time, J. Air Poll. Control Assoc. 20:603-608.

19. Heisler, S. L., Friedlander, S. K., and Husar, R. B. (1973) The relationship of smog aerosol size and chemical element distributions to source characteristics, Atmos. Environ. 7:633-649.

20. Meszaros, Agnes, and Vissy, K. (1974) Concentration, size distributions, and chemical nature of atmospheric aerosol particles in remote oceanic areas, Aerosol. Sci. 5:101-109.

21. Orr, C., Jr., Hurd, F. K., and Corbett, W. J. (1958) Aerosol size and relative humidity, J. Colloid. Sci. 13:472-482.

22. Winkler, P., and Junge, C. E. (1971) Comments on anomalous deliquescence of sea spray aerosols, J. Appl. Meteorol. 10:159-163.

23. Winkler, P., and Junge, C. E. (1972) The growth of atmospheric aerosol particles as a function of the relative humidity - Part 1: Method and measurements at different locations, J. Rech. Atmos. (Memorial Henri Dessens), 6:619-638.

24. Winkler, P. (1973) The growtn of atmospheric aerosol particles as a function of the relative humidity - Part II: An improved concept of mixed nuclei, Aerosol Science 4:373-387.

25. Fitzgerald, J. W. (1975) Approximation formulas for the equilibrium size of an aerosol particle as a function of its dry size and composition and the ambient relative humidity, J. Appl. Meteorol. 14:1044-1049.

26. Hänel, Gottfried (1968) The real part of the mean complex refractive index and the mean density of samples of atmospheric aerosol particles, Tellus 20:371-379.

27. Hänel, Gottfried (1972) Computation of the extinction of visible radiation by atmospheric aerosol particles as a function of the relative humidity, based upon measured properties, Aerosol Sci. 3:377-386.

28. Hänel, Gottfried (1976) The properties of atmospheric aerosol particles as functions of the relative humidity at thermodynamic equilibrium with the surrounding moist air, in Advances in Geophysics, 19:73-188. Edited by H. E. Landsberg, and J. Van Mieghem, Academic Press, New York.

29. Keith, C. H., and Arons, A. B. (1954) The growth of sea salt particles by condensation of atmospheric water vapor, J. Meteorol. 11:173-184.

30. Meszaros, A. (1971) On the variation of the size distribution of large and giant atmospheric particles as a function of the relative humidity, Tellus, 23:436-440.

31. Kasten, F. (1969) Visibility forecast in the phase of pre-condensation, Tellus, 21:631-635.

32. Hale, George M., and Querry, Marvin R. (1973) Optical constants of water in the 200-nm to 200 μm wavelength region, Appl. Opt. 12:555-563.

33. Palmer, K. F., and Williams, D. (1974) Optical properties of water in the near infrared, J. Opt. Soc. Amer. 64:1107-1110.

34. Downing, H. D., and Williams, D. (1975) Optical constants of water in the infrared, J. Geophys. Res. 80:1656-1661.

35. Volz, Frederic E. (1972) Infrared absorption by atmospheric aerosol substances, J. Geophys. Res. 77:1017-1031.

36. Volz, Frederic E. (1973) Infrared optical constants of ammonium sulfate, Sahara dust, volcanic pumice, and flyash, Appl. Opt. 12:564-568.

37. Fischer, K. (1973) Mass absorption coefficient of natural aerosol particles in the 0.4-2.4 μm wavelength interval, Beitr. Physik Atmos. 46:89-100.

38. Fischer, K. (1976) The optical constants of atmospheric aerosol particles in the 7.5-12 μm spectral region, Tellus, 28:266-274.

39. Ward, Gray, Cushing, K. M., McPeters, R. D., and Green, A. E. S. (1973) Atmospheric aerosol index of refraction and size altitude distribution from bistatic laser scattering and solar aureole measurements, Appl. Opt. 12:2585-2592.

40. Grams, G. W., Blifford, I. H., Gillette, D. A., and Russell, P. B. (1974) Complex index of refraction of airborne soil particles, J. Appl. Meteorol. 13:459-471.

41. Pueschel, R. F., and Kuhn, P. M. (1975) Infrared absorption of tropospheric aerosols: Urban and rural aerosols of Phoenix, Arizona, J. Geophys. Res. 80:2960-2962.

42. Junge, Christian E. (1963) Air Chemistry and Radioactivity, 382 pp. Academic Press, New York.

43. Bergstrom, R. W. (1973) Comments on the estimation of aerosol absorption coefficients in the atmosphere, Beitr. Physik Atmos. 46:198-202.

44. Pasceri, Ralph E., and Friedlander, S. K. (1965) Measurements of the particle size distribution of the atmospheric aerosol: II Environmental results and discussion, J. Atmos. Sci. 22:577-584.

45. Clark, W. E., and Whitby, K. T. (1967) Concentration and size distribution measurements of atmospheric aerosols and a test of the theory of self-preserving distributions, J. Atmos. Sci. 24:677-687.

46. Shettle, E. P. (1975) Comment on atmospheric aerosol size spectra: Rapid concentration fluctuations and bimodality by T. E. Graedel and J. P. Franey J. Geophys. Res. 80:3050-3051.

47. Twitty, J.T., and Weinman, J.A. (1971) Radiative properties of carbonaceous aerosols, J. Appl. Meteorol. 10:725-731.

48. Junge, C.E. (1972) Our knowledge of the physico-chemistry of aerosols in the undisturbed marine environment, J. Geophys. Res. 77:5183-5200.

49. Junge, C.E., Robinson, E., and Ludwig, F.L. (1969) A study of aerosols in the Pacific air masses, J. Appl. Meteorol. 8:340-347.

50. Junge, C.E., and Jaenicke, R. (1971) New results in background aerosols, studies from the Atlantic expedition of the R.V. Meteor, Spring 1969, J. Aerosol. Sci. 2:305-314.

51. Woodcock, A.H. (1953) Salt nuclei in marine air as a function of altitude and wind force, J. Meteorol. 10:362-371.

52. Volz, Frederic E. (1972) Infrared refractive index of atmospheric aerosol substance, Appl. Opt. 11:755-759.

53. Dorsey, N. Ernest (1940) Properties of Ordinary Water-Substance in all its Phases: Water Vapor, Water and all the Ices, pp 332-338, Am. Chem. Soc. Monograph Series, Reinhold Publishing Corp., New York.

54. Wells, W.C., Gal, G., and Munn, M.W. (1977) Aerosol distributions in maritime air and predicted scattering coefficients in the infrared, Appl. Opt. 16:654-659.

55. Barnhardt, E.A., and Streete, J.L. (1970) A method for predicting atmospheric aerosol scattering coefficients in the infrared, Appl. Opt. 9:1337-1344.

56. Hodges, John A. (1972) Aerosol extinction contribution to atmospheric attenuation in infrared wavelengths, Appl. Opt. 11:2304-2310.

57. Manson, J.E. (1965) Aerosols, in Handbook of Geophysics and Space Environments, Edited by S.L. Valley, Air Force Cambridge Research Laboratories, United States Air Force, pp 5-22 to 5-27.

58. Junge, C.E. (1957) Aerosols, in Handbook of Geophysics for Air Force Designers, Geophysics Research Directorate, Cambridge Research Center, United States Air Force, pp 8-6 to 8-12.

59. Junge, C.E. (1958) Atmospheric Chemistry in Advances in Geophysics, Edited by H.E. Landsberg and J. Van Mieghem, 1-108, Academic Press, New York.

60. Deirmendjian, D. (1964) Scattering and polarization properties of water clouds and hazes in the visible and infrared, Appl. Opt. 3:187-196.

61. Khrgian, A.K.A., and Mazin, I.P. (1952) The drop size distribution in clouds, Trudy Tsent. Aerolog. Observ. 7:56-61.

62. Lovett, R.F. (1975) The Occurrence of Airborne Sea-Salt and its Meteorological Dependence, M. Sc. Thesis, Institute of Offshore Engineering, Heriot-Watt University, Edinburgh.

63. Lovett, R.F. (1978) Quantitative measurement of airborne sea-salt in the North Atlantic, Tellus, 30:358-364.

64. Byers, H.R. (1959) General Meteorology, 540 pp, McGraw Hill, New York.

65. Silverman, B.A., and Sprague, E.D. (1970) Airborne measurement of in-cloud visibility, pp 271-276, Second National Conference on Weather Modification, Santa Barbara, California, 6-9 April 1970, American Meteorological Society.

66. Dyanchenko, P.V. (1962) Experimental Application of the Method of Mathematical Statistics to Microstructural Fog and Cloud Research, Trans. by A.I. Voyekova, Main Geophys. Obser.

67. Pilié, R.J., Mack, E.J., Kocmond, W.C., Rogers, C.W., and Eadie, W.J. (1975) The life cycle of valley fog. Part I: Micrometeorological characteristics, J. Appl. Meteorol. 14:347-363.

68. Pilié, R.J., Mack, E.J., Kocmond, W.C., Eadie, W.J., and Rogers, C.W. (1975) The life cycle of valley fog. Part II: Fog microphysics, J. Appl. Meteorol. 14:364-374.

69. Arnulf, A., Bricard, J., Cure, E., and Veret, C. (1957) Transmission by haze and fog in the spectral region 0.35 to 10 microns, J. Opt. Soc. Am. 47:491.

70. Kurnick, S.W., Zitter, R.N., and Williams, D.B. (1960) Attenuation of infrared radiation by fogs, J. Opt. Soc. Am. 50:578-583.

71. Mie, G. (1908) Beiträge zur Optik trüber Medien speziell Kolloidaler Metallösungen, Ann. Physik, 25:377-445.

72. van de Hulst, H.C. (1957) Light Scattering by Small Particles, 470 pp, John Wiley & Sons, New York.

73. Kerker, M. (1969) The Scattering of Light, 666 pp, Academic Press, New York.

74. Deirmendjian, D. (1969) Electromagnetic Scattering on Spherical Polydispersions, 290 pp, American Elsevier, New York.

75. Dave, J.V. (1968) Subroutines for Computing the Parameters of Electromagnetic Radiation Scattered by a Sphere, IBM Scientific Center, Palo Alto, California, Report No. 320-3237, May 1968.

76. Hansen, J.E., and Travis, L.D. (1974) Light scattering in planetary atmospheres, Space Sci. Rev. 16:527-610.

77. Blättner, W. (1972) Utilization Instruction for Operation of the Mie Programs on the CDC-6600 Computer at AFCRL, Radiation Research Associates, Ft. Worth, Texas, Res. Note RRA-N7240.

78. Kattawar, G.W., and Plass, G.N. (1967) Electromagnetic scattering for absorbing spheres, Appl. Opt. 6:1377-1382.

79. Hodkinson, J.R., and Greenfield, J.R. (1965) Response calculations for light-scattering aerosol counters and photometers, Appl. Opt. 4:1463.

80. Quenzel, H. (1969) Influence of refractive index on the accuracy of size determination of aerosol particles with light-scattering aerosol counters, Appl. Opt. 8:165.

81. Pinnick, R.G., Rosen, J.M., and Hofmann, D.J. (1973) Measured light-scattering properties of individual aerosol particles compared to the Mie scattering theory, Appl. Opt. 12:37.

82. Cooke, D.D., and Kerker, M. (1975) Response calculations for light-scattering aerosol particle counters, Appl. Opt. 14:734.

83. Chýlek, P., Grams, G.W., and Pinnick, R.G. (1976) Light-scattering by irregularly randomly oriented particles, Science 193:480-482.

84. Holland, A.C., and Gagne, G. (1970) The scattering of polarized light by polydisperse systems of irregular particles, Appl. Opt. 9:1113-1121.

85. Middleton, W.E.K. (1952) Vision Through the Atmosphere, 250 pp, Univ. of Toronto Press.

86. Johnson, J.C. (1951) Physical Meteorology, 393 pp, The M.I.T. Press, Cambridge, Massachusetts.

87. Shettle, E.P., and Weinman, J.A. (1970) The transfer of solar irradiances through inhomogeneous turbid atmospheres evaluated by Eddington's approximation, J. Atmos. Sci. 27:1048-1055.

88. Joseph, J.H., Wiscombe, W., and Weinman, J. (1976) The delta-Eddington approximation for radiative flux transfer, J. Atmos. Sci. 33:2452-2459.

89. Irvine, W.M. (1968) Multiple scattering by large particles. II. Optically thick layers. Astrophys. J. 152:823-834.

90. Wiscombe, W.J., and Grams, G. (1976) The back-scattered fraction in two-stream approximations, J. Atmos. Sci. 33:2440-2451.

91. Henyey, L.G., and Greenstein, J.L. (1941) Diffuse radiation in the galaxy, Astrophys. J. 93:70-83.

92. Hansen, J.E. (1969) Exact and approximate solutions for multiple scattering clouds, J. Atmos. Sci. 26:478-487.

93. Flowers, E.C., McCormick, R.A., and Kurfis, K.R. (1969) Atmospheric turbidity over the United States, 1961-1966, J. Appl. Meteorol. 8:955-962.

94. Filippov, V.L., and Mirumyants, S.O. (1972) Aerosol extinction of visible and infrared radiation as a function of air humidity, Izv. Atmos. Oceanic Phys. 8:571-574.

95. Kasten, F (1968) Falling speed of aerosol particles, J. Appl. Meteorol. 7:944-9

☆U.S. GOVERNMENT PRINTING OFFICE: 1980—600-019/16